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EU Forest-based biomass for energy: cost/supply relations and constraints

Joensuu, 18-19 September 2007

Editors: M. Szabo, R. Edwards

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METLA Metsäntutkimuslaitos Skogsforskningsinstitutet Finnish Forest Research Institute

Proceedings of the Expert Consultation

"EU Forest-based biomass for energy: cost/supply relations and constraints"

Joint Research Centre of the European Commission IES JRC (www.jrc.cec.eu.int)
EFI, European Forest Institute (www.efi.int)
METLA, The Finnish Forest Research Institute (www.metla.fi)

Joensuu, Finland
18-19 September 2007,

The mission of the Institute for Environment and Sustainability is to provide scientific-technical support to the European Union's Policies for the protection and sustainable development of the European and global environment.

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Institute for Environment and Sustainability

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Acknowledgement

The Expert Consultation on "EU Forest-Based Biomass for Energy: Cost/Supply Relations and Constraints" was held at the METLA in Joensuu (Finland) on 18-19 September 2007. The meeting was organised by the Biofuels Action of the *Renewable Energies Unit (Institute for Environment and Sustainability, Joint Research Centre, European Commission), in collaboration with the European Forest Institute and The Finnish Forest Research Institute*. The organisers express their thanks for the input of all participants.

Special thanks to

- *Mr. Marcus Lindner* (*European Forest Institute, EFI*) and his technical team
- *Prof. Antti Asikainen* (*The Finnish Forest Research Institute, METLA*) for the contribution to the success of the Workshop
- *Mr. Jouko Parviainen* (*Wood Energy Net*) and the *Eno Energy* team for organising the technical visit
- *Mr. H. Ossenbrink* (Head of JRC Renewable Energies Unit) for his support and to
- *Mrs. Brita Pajari (European Forest Institute)* for the local organisation.

The digital version of the Meeting Proceedings can be found on the BioFuel web site (http://re.jrc.ec.europa.eu/biof/). The cover illustration was provided by Antti Asikainen (METLA).

October 2007

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"EU Forest-based biomass for energy: cost/supply relations and constraints"

Motivation

Expert Consultation
"EU Forest-based biomass for energy: cost/supply relations and constraints"

Place: Joensuu, Finland

Date

18-19 Sept 2007.
1.5 days workshop + 0.5 day field trip

Background

This Expert Consultation is organised by the Institute for Environment and Sustainability (IES) of the Joint Research Centre (JRC) of the European Commission (www.jrc.cec.eu.int) in cooperation with the European Forest Institute (www.efi.fi)

Motivation

The European Commission faces a range of estimates for the amount of biomass which could be supplied by EU forestry in 2020. Estimates are needed directly as a basis for establishing renewable energy targets, and indirectly for modelling in support of renewable energy policy.

Here we are concerned with forest resources from commercial forests, which can be used on an industrial scale, not traditional firewood wood for domestic use. Use for energy comprises heating boilers, cogeneration of heat + electricity, electricity from co-firing, electricity from dedicated power stations (without use of heat) and conversion to biofuels for transport.

We want to focus discussion on *cost-supply curves* for forest resources. This is to counter the misconception, propagated by simplified bio-energy assessments, that resources from the forest have a more-or-less fixed cost, and that they are available this cost up to a limit of availability determined by the size of EU forests. As explained below, we also think that experts can more easily reach consensus on availability when there is a clear definition of the cost level under consideration.

The historic tendency has been for estimates of energy resources from forestry sector to fall with time: [Lundmark 2004] points out that over 10 years estimates of forest residue resource in Sweden (by various institutes) decreased by a factor 5. The same trend can be seen in estimates for EU. More modern studies tend to look in more detail at what proportion of the theoretically available biomass in forests can technically, environmentally and economically be collected. Accordingly, we think it is appropriate to consider only recent original studies, and not meta-studies based on older estimates.

Three recent original studies devoted to availability in EU are:-

- [METLA 2004] from Finnish Forest Institute (EFI): EU-25
- [EFFECT 2004], a confidential study of exploiting EU-15 forests for EU energy, for DG-ENV, prepared by ECOFYS, probos and EFI

- [EEA 2006] “How much biomass can Europe produce without harming the environment?”, which summarizes forest resources estimated by EFI.
- [EEA 2007] “Environmentally compatible bio-energy potential from European Forests”, which gives details behind the estimates summarized in. [EEA 2006].
- [Mantau 2007] Prof. Dr. Udo Mantau “The legend of the woody biomass reserve in Europe” UNECE Workshop “Mobilizing Wood Resources” Geneva January 11-12, 2007

The studies identify four potential sources of EU forest resources for energy use:-

1. Residues from roundwood felling
2. Extra (or “complimentary”) roundwood felling, using part of the net roundwood increment (and associated residues).
3. Roundwood diverted from existing wood/paper/pulp industries

The first three studies above agree fairly well on how much of each of these resources is theoretically available, but they disagree about *which fraction of this is collectable* and would be available for energy use. [Mantau 2007] thinks the complimentary felling potential is seriously overestimated in the other studies.

Residues from felling: comparison
[EEA 2006] proposes 50% is “environmentally” available, [METLA 2004] estimates only 36% can technically be collected and [EFFECT 2004] concludes that only 15% is recoverable “in a sustainable and feasible way”. [Lundmark 2004] points out that there is no incentive to collect more residues if this costs more than roundwood.

Complimentary felling: comparison
[Mantau 2007] states that the theoretical potential is over-estimated in the other studies because of mixing over-bark and under-bark figures, not accounting for harvest losses and unregistered felling. [EEA 2006] propose that nearly 50% of their estimated roundwood balance is “environmentally” available for energy, whereas [METLA 2004] consider that only 25% of it would be technically available. [EFFECT 2004] states that 40% of any increase in EU15 fellings could go to energy use; the rest would be used by existing industries, on the assumption that they could afford to pay more for wood of suitable quality. They say, however, that EU15 fellings are unlikely to increase because of competition from NMSs and outside EU25.
[EEA 2006] includes thinnings in complementary fellings, but other studies consider them too expensive to collect.

Roundwood diverted from existing wood/paper/pulp industries
[METLA 2004] and [EFFECT 2004] assume that no wood will be diverted from existing industries, whereas [EEA 2006] estimate that this could amount to 2Mtoe wood.

We think the main reason for the differences between studies in the proportion of theoretically-available resource which is practically collectable is that different studies are considering *different points on the cost-supply curve*. If we compare what resources are available *at a given cost* we will find much greater consensus.

Accordingly, the main target of this consultation is to attempt to reach consensus on cost-supply curves for forest resources in EU 2020 (with associated error margins).

In 2006, JRC constructed approximate cost-supply curves for forest resources in EU25-2020 for use inside the Commission. These took the maximum availabilities for different EU25 regions derived from [METLA 2004], and linked these to a distribution of costs. Costs for different regions of EU25 were based on data from [Lundmark 2004], [METLA 2004], and checked against French Industry sources.

The main spread in roadside cost is due to the range of forwarding distances costs, as demonstrated by [Lundmark 2004]. Collection, chipping and administration costs were added. JRC took his cost spread for Sweden and adjusted it for relative costs in other EU regions using data from [METLA 2004], and rough estimates of road network density. Then JRC added road-transport costs for various plant capacities, depending on regionalized cost-per-km and resource density.

Note that plant size is very important for BIOFUELS. Stand-alone plants for making biofuels out of biomass would have to be very large to justify the investment in complex plant. This increases supply transport distances and logistical problems compared to biomass for heat end electricity conversion.

[EEA 2007] gives cost data from EFI not quoted in [EEA 2006]. It shows availability of wood from EU25 as a function of cost delivered to existing processing plants. EFI used a sophisticated economic model of forestry costs to arrive at these figures. They are not exactly comparable with the JRC cost-supply curves, because they are for a range of effective plant capacities. However, in general the costs are not dissimilar for the same volume of supply. The main difference is that the EEA curves continue to higher levels of supply and higher costs, whereas the JRC curves terminate at the METLA availability limits.

The first aim of this consultation is to audit the assumptions used by EFI and by JRC, and so to arrive at a consensus on EU25-2020 cost supply curves within an agreed error range.

Once the cost-supply curves are established, we can use them for many purposes:

- effect of increased bioenergy (including 2nd generation biofuels) production on EU wood prices
- estimating import penetration at different levels of bioenergy use
- amount of wood diverted from existing uses
- optimization of plant size for different types of conversion plant
- cost-supply curves as input data for models of resource use (e.g. GREEN-X).

The experts will discuss the extra input data required and methodology needed for these extensions.

The experts will then be invited to discuss related matters, as time permits:

- Transport logistic limitations for large plants.
- Future developments in costs: are learning curves appropriate?
- Where can we take stumps?
- What does taking residues do to the stock of carbon in forest soils?
- What does more felling do to the stock of carbon in forest soils?

REFERENCES

[Lundmark 2004] R. Lundmark, IIASA interim report IR-03-059
"The supply of forest-based resources for the energy sector: the case of Sweden" April 2004 download at www.iiasa.ac.at
[METLA 2204] T. Karjalainen et al. "Estimation of Energy Wood Potential in Europe" Finnish Forest Institute, (METLA) www.metla.fi ISBN 951-40-1939-3
[EEA 2006] "How much energy can Europe produce without harming the environment" ISSN 1725-9177
[EEA 2007] "Environmentally compatible bio-energy potential from European forests"
[Mantau 2007] Prof. Dr. Udo Mantau "The legend of the woody biomass reserve in Europe" UNECE Workshop "Mobilizing Wood Resources" Geneva January 11-12, 2007

NOTE

Since there are different conventions for conversion to energy units, we suggest participants bring their results already expressed in solid cubic metres.

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Expert Consultation

Joint Research Centre, European Commission, JRC-EC
European Forest Institute, EFI
The Finnish Forest Research Institute - Metla

"EU Forest-based biomass for energy: cost/supply relations and constraints"

18-19 September 2007,
Joensuu, Finland

Agenda (September 2007-V5)

18 September 2007

<table>
<tr><td colspan="2">Session of Introduction
Chair: Robert Edwards, European Commission, Joint Research Centre
Marcus Lindner, European Forest Institute (EFI)</td></tr>
<tr><td>9:00 am - 9:30</td><td>Welcome address by Jary Parviainen, Director of METLA/Joensuu
Introduction of participants
Introduction and objective of the meeting, by Robert Edwards (JRC)</td></tr>
<tr><td>9:30 – 10:00</td><td>METLA Method</td></tr>
<tr><td>10:00 - 10:30</td><td>EFI Method</td></tr>
<tr><td>10:30 – 10:45</td><td>Coffee break</td></tr>
<tr><td colspan="2">First session
Roundwood harvest projections to 2020
Forest residues
Main topics: Expansion factors; absolute technical constraints (e.g. % which can be picked up); Environmental constraints; Cost of collection, cost of forwarding per tonne-km; Supply vs. forwarding distance; Road transport costs (per tonne-km); Transport distance to existing plant; Transport mean distance vs. plant size for larger plants; Thinning; Stumps; Administration costs
Rapporteur:</td></tr>
<tr><td>10:45 – 12:00</td><td>Discussion</td></tr>
<tr><td>12:00 – 13:30</td><td>Lunch break</td></tr>
<tr><td>13:30 – 15:30</td><td>Continuation of the discussion</td></tr>
<tr><td>15:30 - 15:45</td><td>Coffee break</td></tr>
</table>

<table>
<tr><td colspan="2">Second session
Complementary fellings
Main topics: Growth increment estimate, Wood industry use projection;
Accounting: - "unrecorded" fellings
- overbark vs. underbark,
- kerf
Technical and environmental constraints (absolute): soil, slope, access… etc. Costs of harvesting, costs of forwarding (tonne- km); Forwarding distance as a function of supply and road network density; Supply vs. forwarding distance; Road transport costs tonne-km; Transport distance to existing and larger plants as a function of supply; Administration costs
Rapporteur:</td></tr>
<tr><td>15:45 – 18:00</td><td>Discussion</td></tr>
</table>

19:00 -22:00	Dinner at EFI

19 September 2007

Third session as time permits **Future progression in specific costs (harvesting, forwarding….)** *Main topics:* Extensions: What more do we need to know to predict - effect of increased wood-chip demand on wood prices - Interaction with import cost/supply curve - Diversion of wood from existing uses - Optimization of plant size (from different types of conversion plant) - forest owner attitudes: can we assume "market" behaviour? - potential to increase forest output by managing stand age and fertilization - Any Other Business – forest soil effects *Rapporteur:*	
09:00 – 10:45	Discussion
10:45 – 11:00	Coffee break

Fourth session **Reports and conclusions** *Rapporteur:*	
11:00 – 11:45	Reports session 1-3 (Optional)
11:45 – 12:00	Concluding remarks

12:00 – 13:00	Lunch

13:00 - 17:00	**Technical visit (optional)** to Eno Energy Cooperatives harvesting sites and heat plant. See the whole chain from forest – harvesting – chipping – transportation – to the heating plan.
	1. Visit to energy wood harvesting site: Silvicultural aspects and harvesting technology 2. Storage and Chipping of material 3. Visit to the heat plant and presentation of heat entrepreneurship in Eastern Finland.
Return to Joensuu airport at 17:00	

Expert consultation

"EU Forest-based biomass for energy: cost/supply relations and constraints"

Presentations

APPROXIMATE COST-SUPPLY CURVE FOR EXTRA EU FOREST CHIPS IN 2020

Robert Edwards

robert.edwards@jrc.it

Scope: **extra** resources from forests, for input to bioenergy policy (= bioelectricity + bioheat + biofuels)

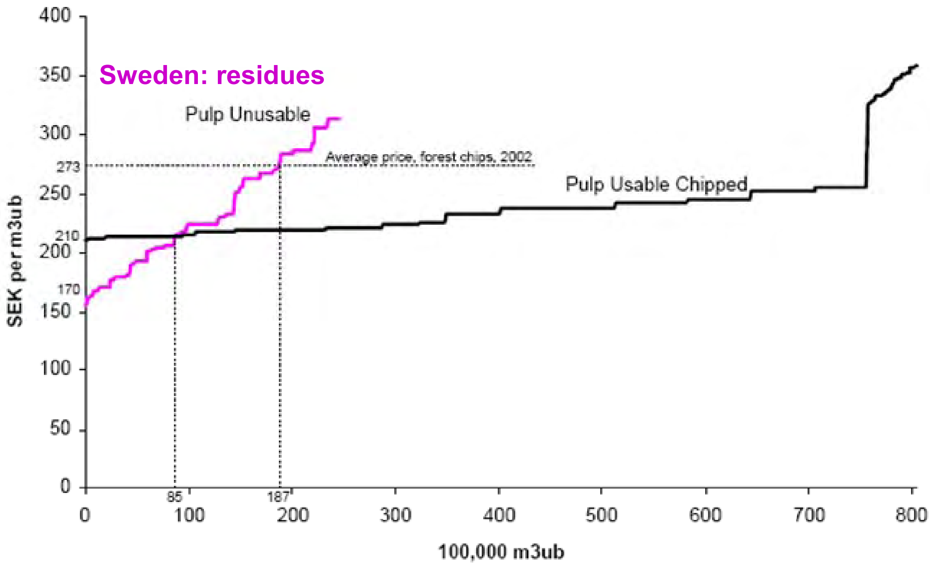
- Includes
  - Forest residues
  - Additional (=complimentary) felling
- Does NOT include
  - traditional firewood
  - crop residues (straw etc.)
  - farmed wood (SRF) on agricultural land
  - "wastes" produced at processing plant (bark, sawdust…) because these are already used.
- Afterwards I should subtract the forest residues already used.

1. Forest residues

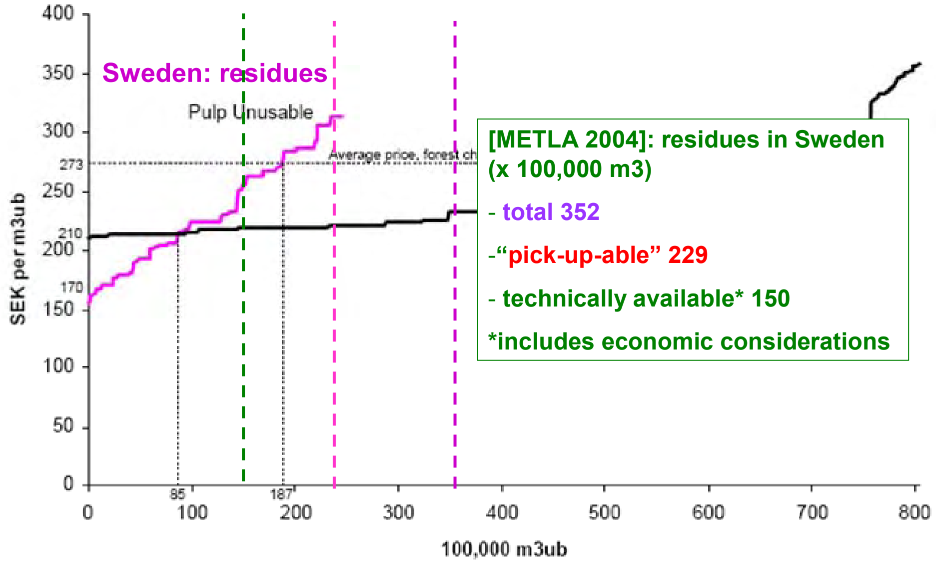
- The only credible national cost supply curve I could find at the time was from Robert Lundmark "The supply of forest-based biomass for the energy sector: the case of Sweden." International Institute for Applied Systems Analysis, (IIASA) Interim report IR-03-059, www.iiasa.ac.at April 2004

- Roadside cost includes:
  - Collection and chipping
  - Owners' compensation
  - Returning ash to the forest (?)

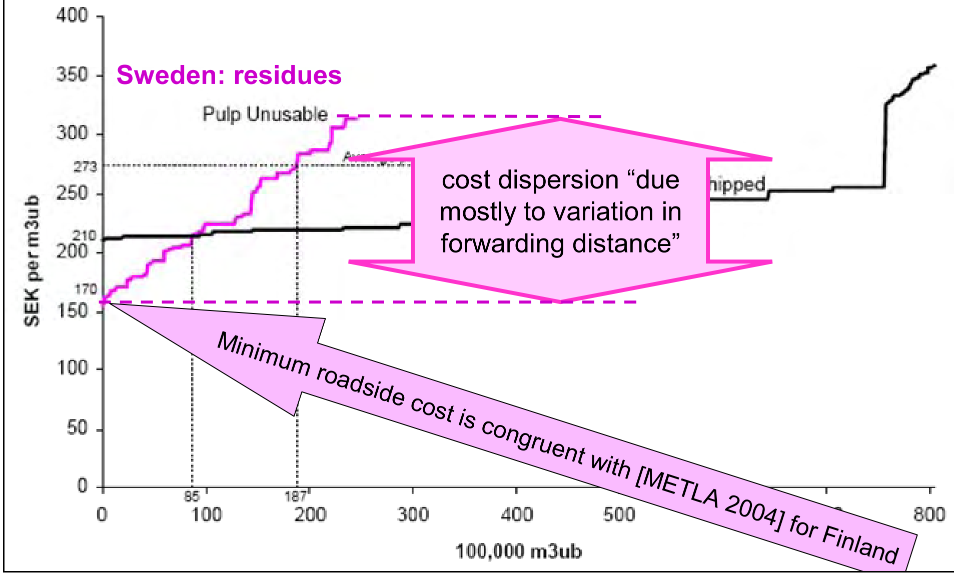
[R. Lundmark 2004]: Roadside cost of forest chips vs. supply for Sweden



[R. Lundmark 2004]: Roadside cost of forest chips vs. supply for Sweden



[R. Lundmark 2004]: Roadside cost of forest chips vs. supply for Sweden



EU ***roadside*** cost-supply curve…

- For Sweden and Finland, I linearized Robert Lundmark's cost-supply curve and added the pick-up-able supply for Finland from METLA. Then I added 27% for harvest increase to 2020 (ETTS-V estimate).
- I did the same thing to get maximum technical availabilities for other EU countries
- Costs: I assumed main variation is forwarding distance.

  New Member States:

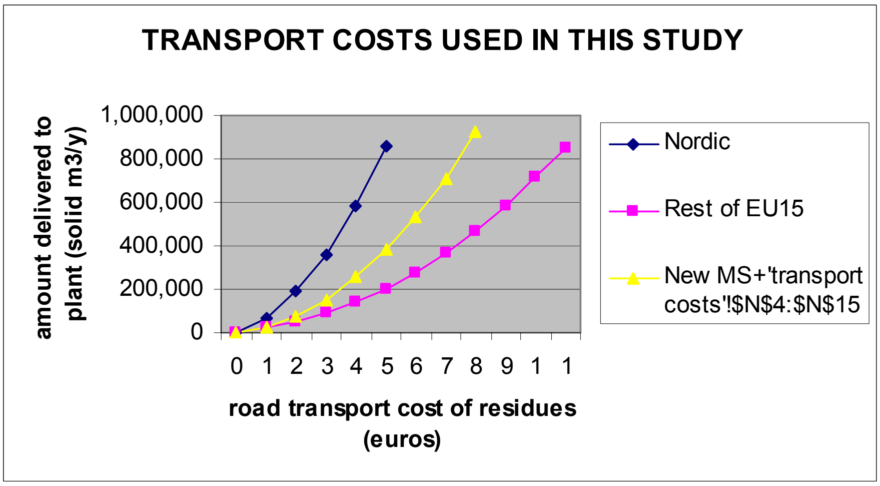
  – Minimum roadside cost from base of METLA's curve of cost vs. plant capacity for Poland.

  – Then I got the maximum roadside cost by adding Lundmark's variation in roadside cost

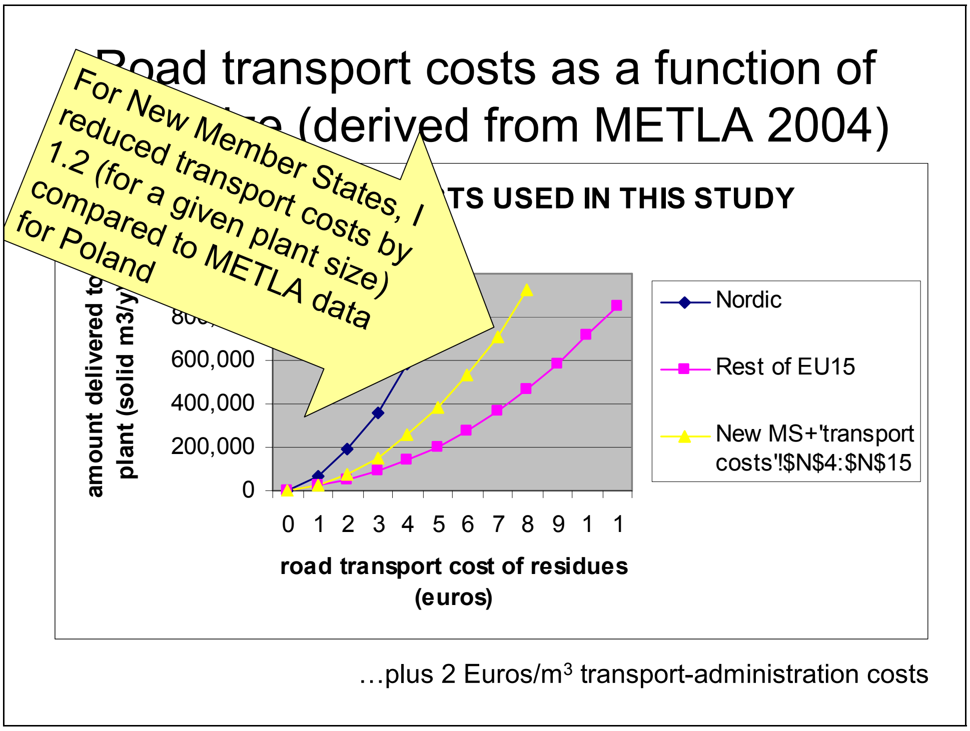
  Rest of EU-15: I added half this variation in roadside cost for (denser road network assumed to limit forwarding distance)

  + 1 Euro/solid m3 administation costs as far as the road.

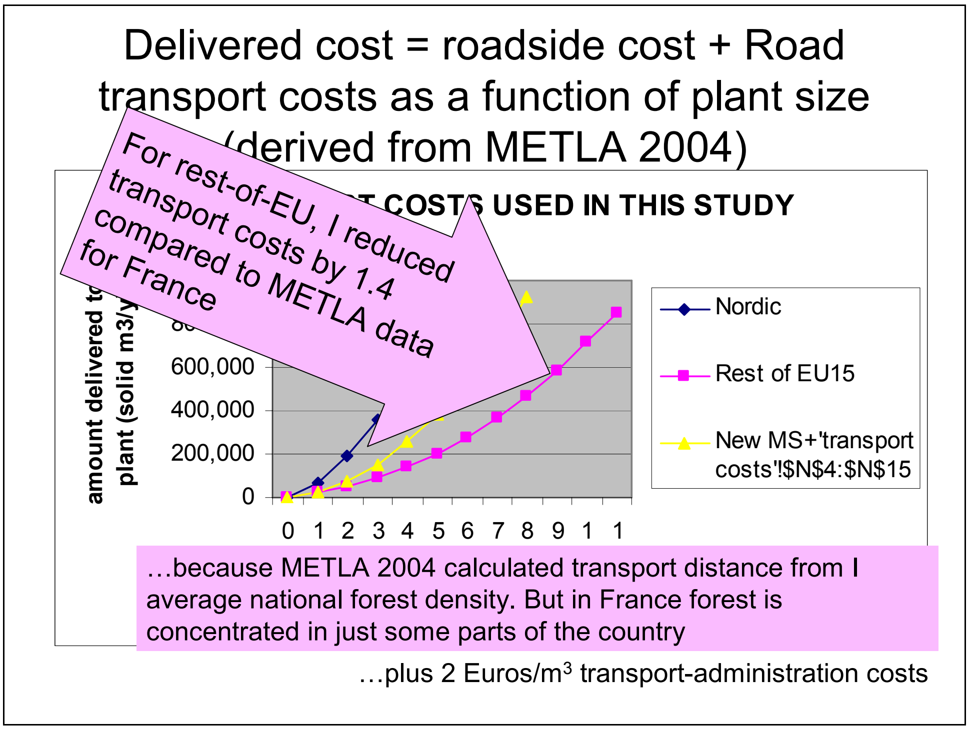
Road transport costs as a function of plant size (derived from METLA 2004)



…plus 2 Euros/m^3 transport-administration costs



Road transport costs as a function of
(derived from METLA 2004)
For New Member States, I reduced transport costs by 1.2 (for a given plant size) compared to METLA data for Poland
TS USED IN THIS STUDY
amount delivered to plant (solid m3/y
600,000
400,000
200,000
0
0 1 2 3 4 5 6 7 8 9 1 1
road transport cost of residues (euros)
Nordic
Rest of EU15
New MS+'transport costs'!$N$4:$N$15
…plus 2 Euros/m³ transport-administration costs



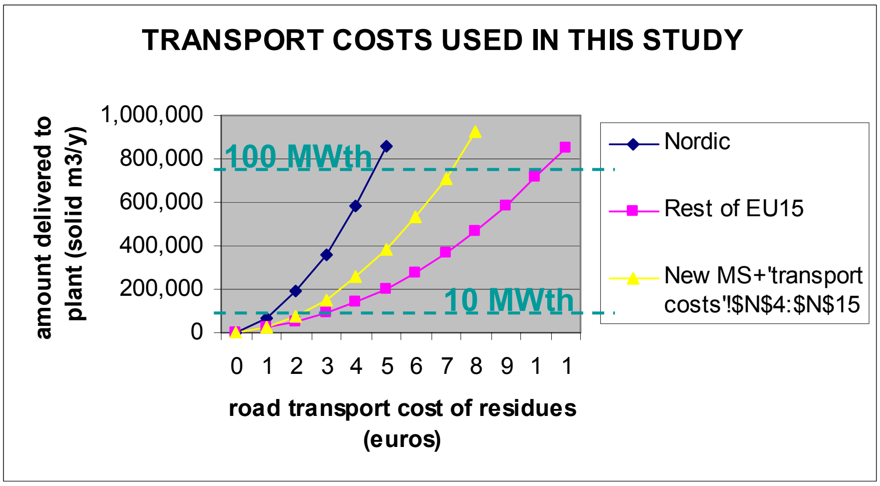
Delivered cost = roadside cost + Road transport costs as a function of plant size (derived from METLA 2004)
For rest-of-EU, I reduced transport costs by 1.4 compared to METLA data for France
COSTS USED IN THIS STUDY
amount delivered to plant (solid m3/y
600,000
400,000
200,000
0
0 1 2 3 4 5 6 7 8 9 1 1
Nordic
Rest of EU15
New MS+'transport costs'!$N$4:$N$15
…because METLA 2004 calculated transport distance from I average national forest density. But in France forest is concentrated in just some parts of the country
…plus 2 Euros/m³ transport-administration costs

WOOD CONSUMPTION OF DIFFERENT PLANTS

plant size	tonnes/y wood	m3/yr
10MWth plant	31,068	77,670
100MWth plant	310,680	776,699

p.s. apparent discrepancy between EFI and METLA on solid density of forest residues…

Road transport costs as a function of plant size (derived from METLA 2004)



…plus 2 Euros/m^3 transport-administration costs

Roadside cost of complementary fellings

- METLA pulp-wood price 2002

…equals approximately the marinal production cost (?)

- For cheap species:

Sweden, Finland: 23.5 Eur/m^3 (ub?)

+/- 2.5 Eur/m^3 variation in forwarding cost (Lundmark)

+ 3 Eur/m^3 chipping (Lundmark)

= **24 to 29 Eur/m^3**

in line with residuals cost calculation

Rest of EU15: **24 to 32 Eur/m^3**

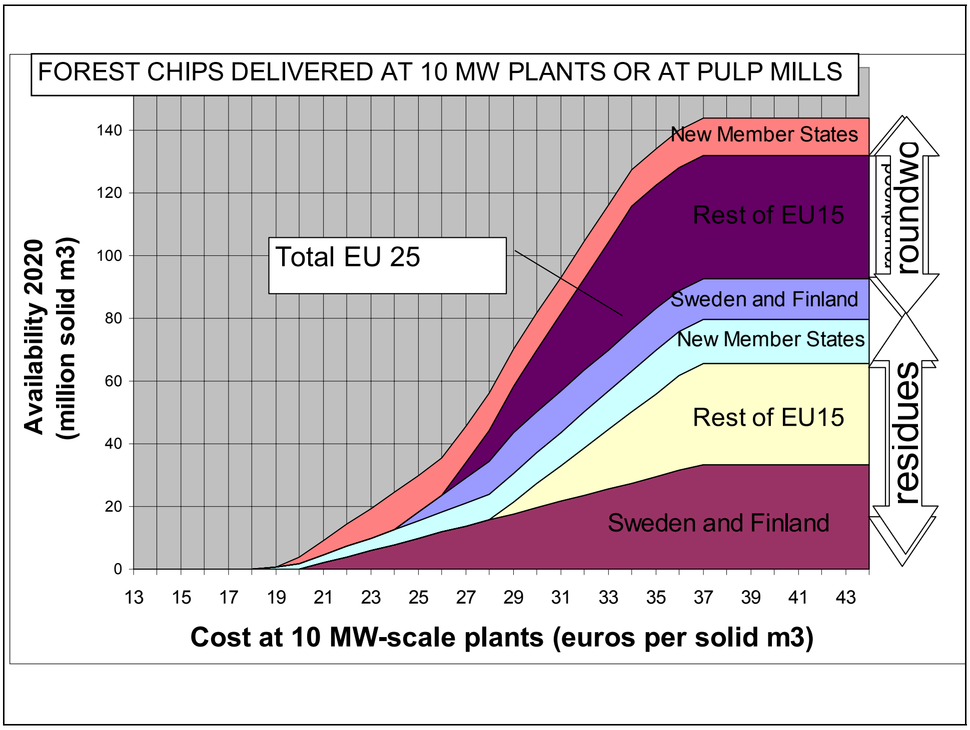
New Member States **18-23 Eur/m^3**

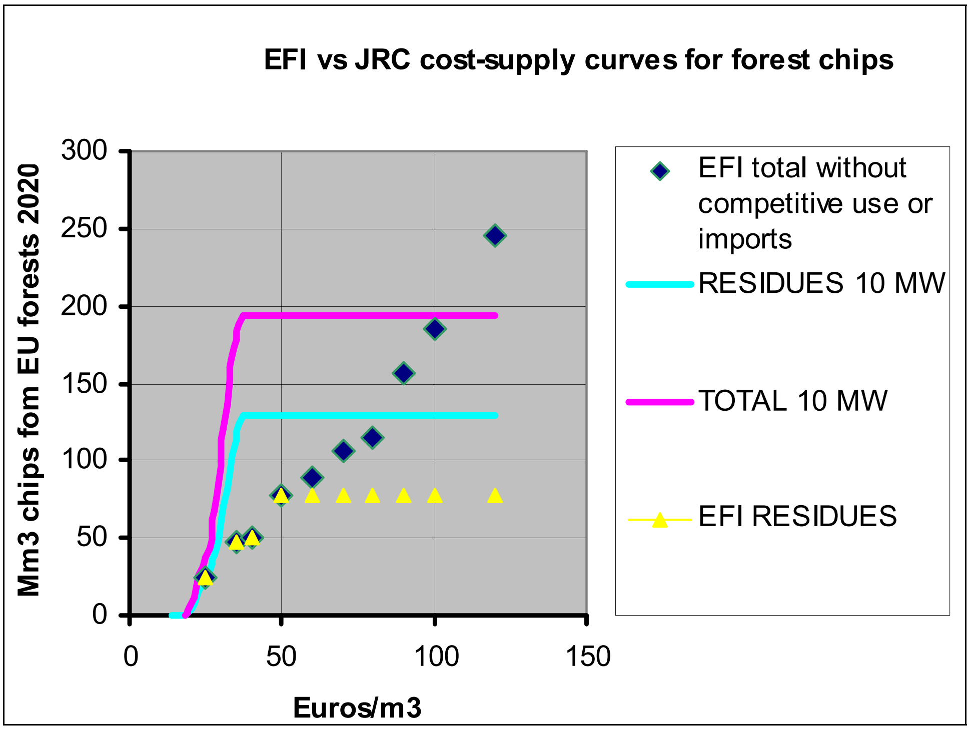
Maximum supply : 25% of growth increment [METLA 2004]

Road Transport cost of fellings: 70% of that for residues

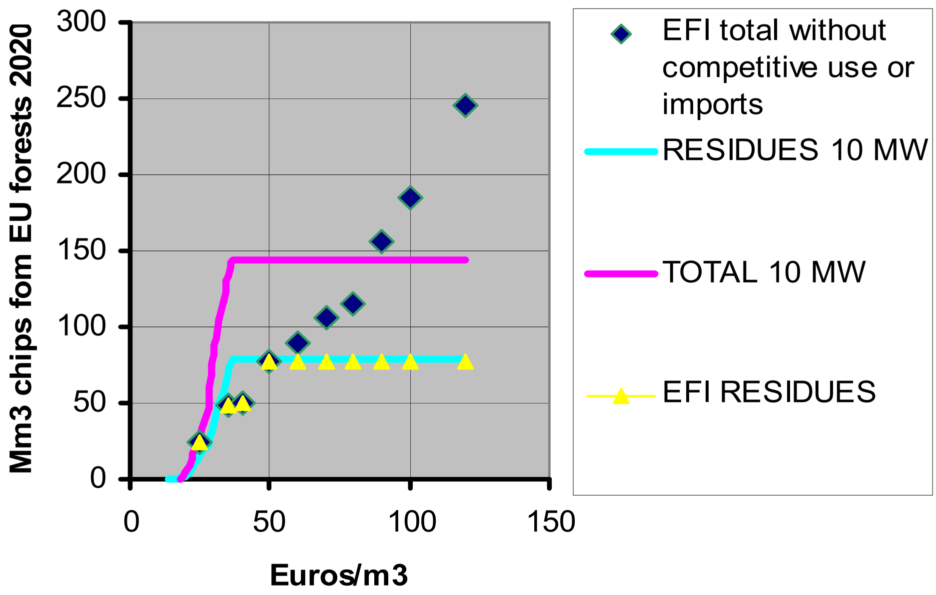
(because cheaper to truck stems and chip at plant)

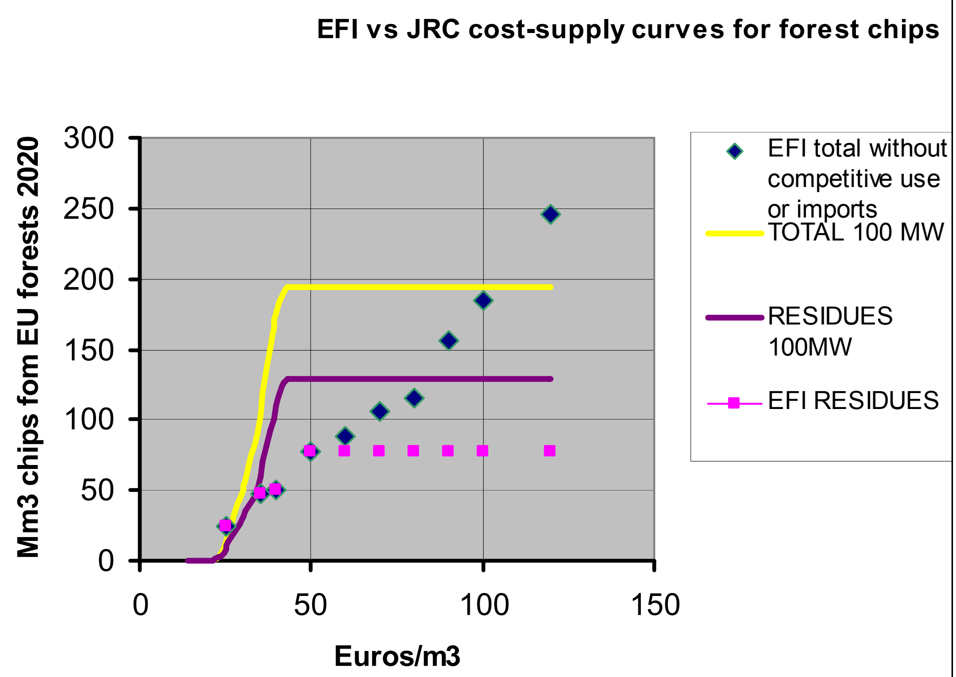
(linear variation of road transport cost with supply assumed: [Lundmark])


FOREST CHIPS DELIVERED AT 10 MW PLANTS OR AT PULP MILLS
Availability 2020 (million solid m3)
140
120
100
80
60
40
20
0
13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43
Cost at 10 MW-scale plants (euros per solid m3)
Total EU 25
New Member States
Rest of EU15
Sweden and Finland
New Member States
Rest of EU15
Sweden and Finland
roundwo
residues

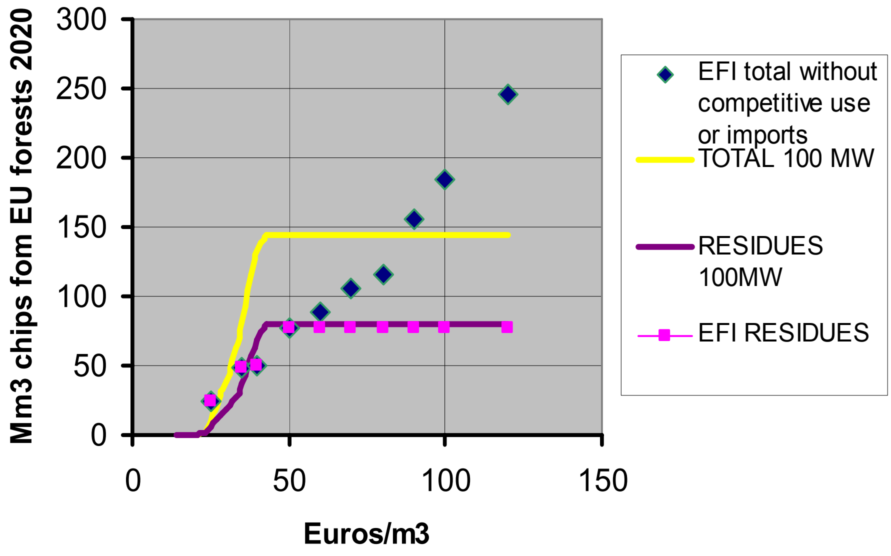

EFI vs JRC cost-supply curves for forest chips
Mm3 chips fom EU forests 2020
300
250
200
150
100
50
0
0 50 100 150
Euros/m3
EFI total without competitive use or imports
RESIDUES 10 MW
TOTAL 10 MW
EFI RESIDUES

…using METLA technically available residues instead of METLA recoverable residues…





…using METLA technically available residues instead of METLA recoverable residues: 100MW plant



EUROPEAN FOREST INSTITUTE

Marcus Lindner, Alexander Moiseyev, Jeannette Meyer, Giuliana Zanchi

Environmentally compatible bio-energy potential from European forests

Methods and key assumptions
of the EEA assessment
JRC/EFI/METLA workshop Joensuu, 18-19 Sept. 2007

www.efi.int

Objectives of the study were

- To review environmental constraints for bio-energy utilization
- To quantify the constraints at the European level
- To assess environmentally compatible resource potentials for bio-energy from forests in Europe (EU25 – CY, EL, MT, LU) at regional (NUTS2) level

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2
03/10/2007

Outline

- Short summary of environmental constraints assessment
- Methods of resource potential calculation

- Short summary of the economic modelling exercise

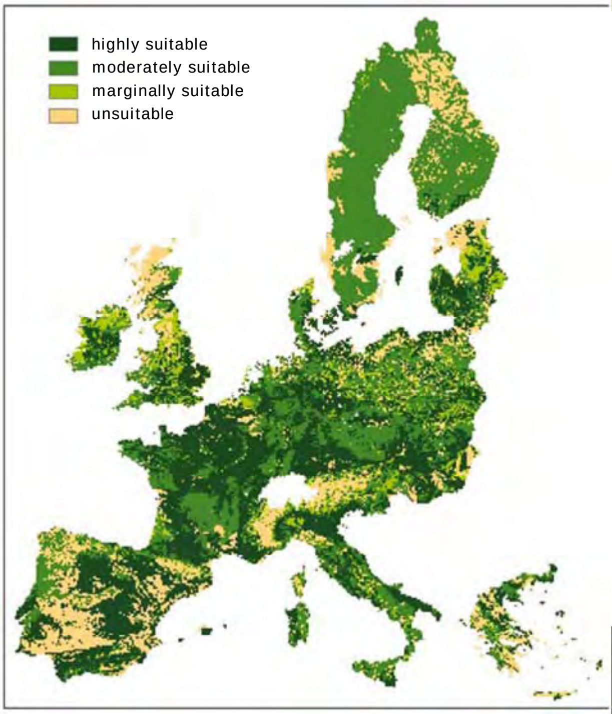
Environmental constraints and related indicators

- Conservation and protection of biodiversity
  (*share of protected areas, amount of deadwood*)
- Sustaining site productivity / Site fertility
  (soil nutrition)
- Soil protection /Soil erosion
  (terrain steepness, sensitivity to soil compaction, ground cover)
- Water protection
  (share of protective forests)
- Other considerations

Environmental criteria in European assessment

Environmental impact	Highly suitable	Moderately suitable	Marginally suitable	Unsuitable
Soil erosion				
Slope	< 5° (< 9%)	5° - 10° (9% - 18%)	10° - 25° (18% - 47%)	> 25° (> 47%)
Elevation	< 1500 m	< 1500 m	< 1500 m	> 1500 m
Soil compaction				
Peat land	No	No	Peat	
Soil water regime	Wet to a depth of 80 cm < 6 months	Wet to a depth of 80 cm < 6 months	Wet to a depth of 80 cm > 6 months	Wet to a depth of 40 cm > 11 months
Soil fertility				
Base saturation				
in topsoil	> 50%	< 50%		
in subsoil	> 50%	< 50%		
Soil type (FAO85 Lv1)	Cambisol Chernozem …	Podzol	Histosol …	Ranker …

Combined suitability map for residue extraction



Evaluation of environmental constraints assessment

- First European scale assessment
- Considerable data limitation at this scale

- Possibility of compensatory fertilization not directly included

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03/10/2007

Assessment of resource potentials

by combining the environmental constraints with resource projections of the EFISCEN model

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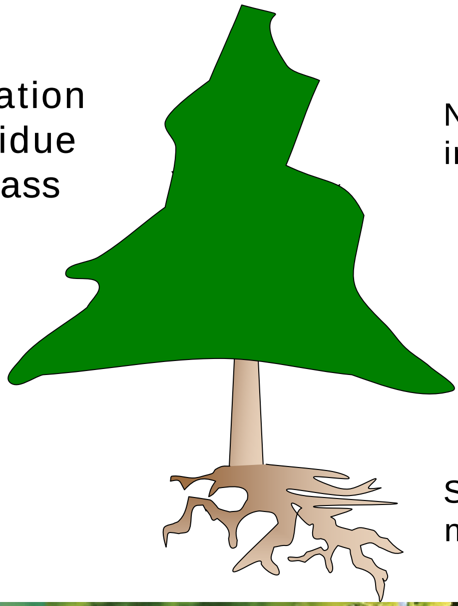
Calculation of residue biomass



Needles not included

Stumps and roots not included

Classification of site suitability for forest residue extraction

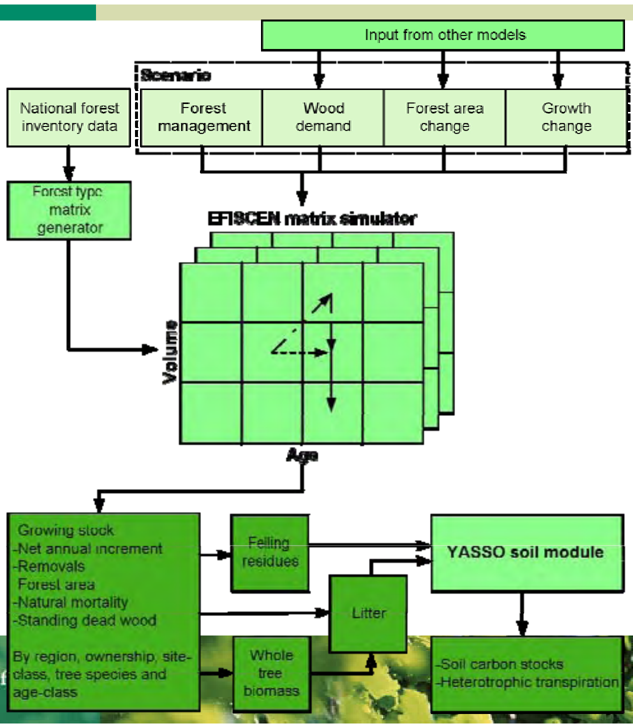
Category	Highly suitable	Moderately suitable	Marginally suitable	Unsuitable
Level of residue extraction *	75%	50%	15%	0%

*Residues in this study = stem tops and branches; foliage and roots are assumed to be left in the forest because of enviromental considerations

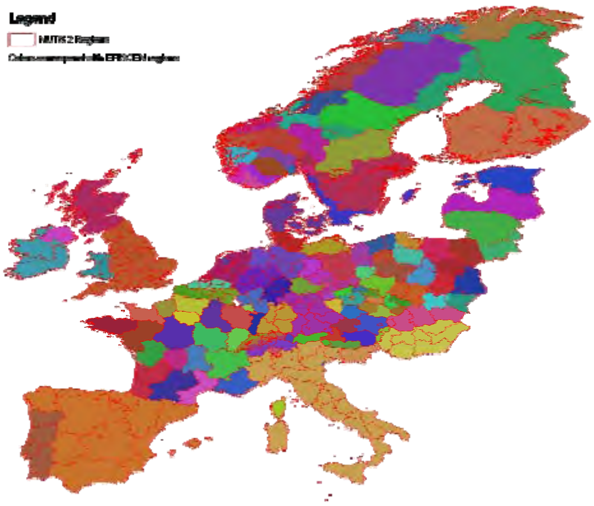
Forest resource assessment: forest residues and complementary fellings

- Application of the large-scale European forest information scenario model EFISCEN (Pussinen et al. 2001, Karjalainen et al. 2003, Nabuurs et al. 2003)

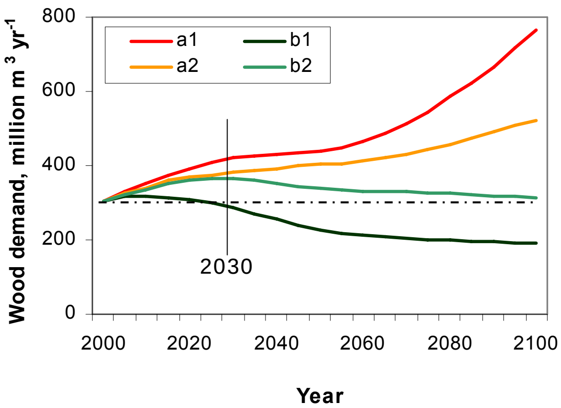
- The model was run for 21 countries (Greece, Luxembourg, Malta, and Cyprus missing)



EFISCEN regional resolution



Wood demand/felling projections are a key assumption



Demand projections from IMAGE 2.2:
Total wood demand in Europe for four SRES scenarios used in the ATEAM project (Eggers et al. 2007)

EFISCEN scenario runs: demand/supply scenarios

B2 Baseline using SRES B2 scenario for projection of changes in demand

MAX Maximum sustainable harvest (calculated with Heyer formula)

MAX-5 Protected area scenario, assuming 5% reduction in managed forest area

MAX-10 Protected area + biodiversity scenario, assuming additional 5% reduction in managed forest area to account for larger amount of deadwood/large old trees in managed stands

Energy potentials in forest residues – baseline scenario

Residues from regular fellings, Mtoe

	2010	2020	2030
Full potential (75% extraction rate)	25.1	26.8	27.4
Environmentally constrained potential	14.9	15.9	16.3

Energy potentials from complementary fellings in 2010: Impact of biodiversity scenarios

Stemwood and residues from complementary fellings, Mtoe

	Stemwood	Felling residues
MAX	31.9	6.7
MAX -5	27.1	5.7
MAX – 10	22.9	4.8

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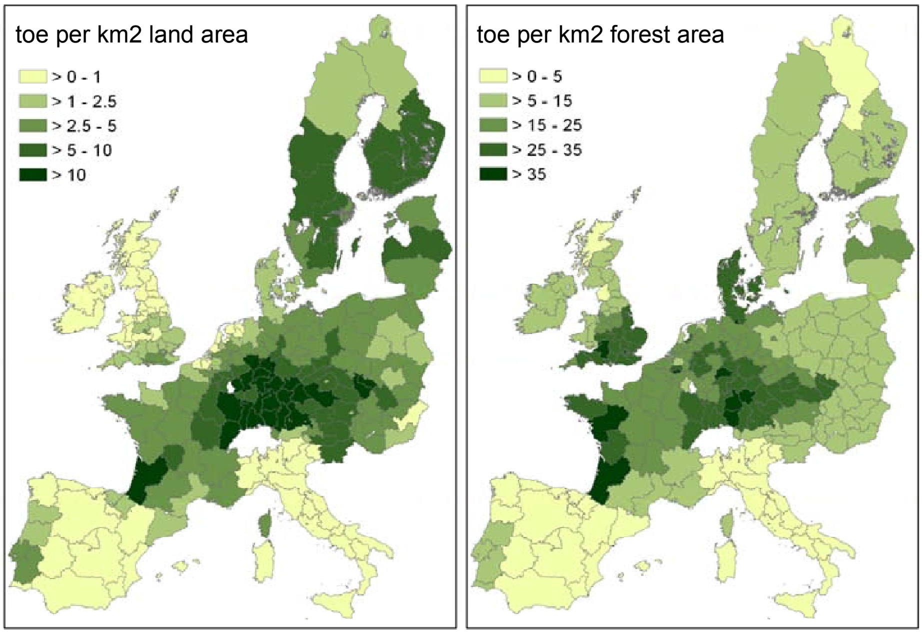
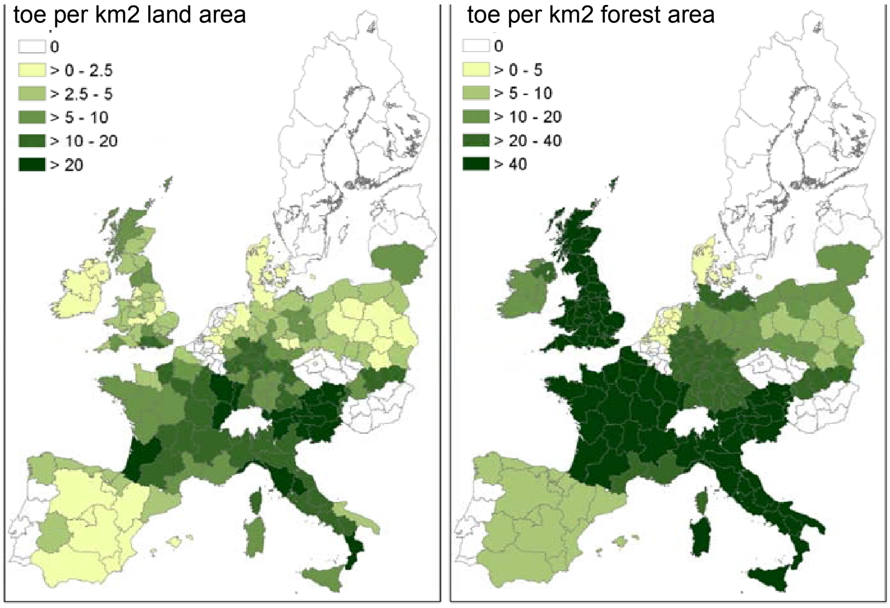
Energy potential from forest residues in 2010



Energy potential in complementary fellings, 2010
protected area & biodiversity scenario



Uncertainties

- Heterogeneous data quality in the EFISCEN input data
- Wood demand projection
- No biodiversity constraint implemented for residue extraction in actively managed forests

- ASSESSMENT RESULTS = POTENTIALS
  PART OF THESE POTENTIALS ALREADY USED
  PART OF THE POTENTIALS CANNOT BE USED

A few comments in response to Prof. Mantau's presentation in Geneva

- Over bark / under bark correction included in EFISCEN (11/13% bark in coniferous and deciduous species)
- Difference between fellings and removals: EFISCEN makes a correction based on TBFRA data
- Unaccounted fellings: valid point, but no data available
- Private owners don't harvest: -> session 3

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Evaluation of resource potential assessment

- Link to EFISCEN allows flexible resource projection with different scenario assumptions
- Limitations because of heterogeneous data basis
- No explicit consideration of socio-economic and technical constraints

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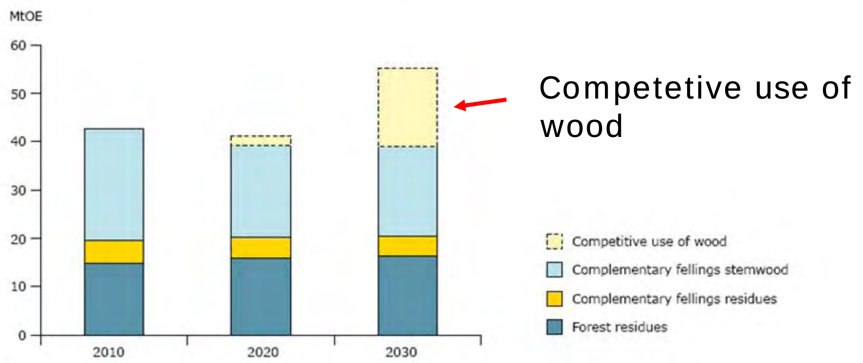
Some explanations on the economic modelling exercise linked to the EEA study

- Cost – supply curves were needed for the EEA bioenergy project as input to the Green-X model projections

- The forest sector model EFI-GTM was applied to estimate cost-supply curves and possible market repercussions

Environmentally-compatible bio-energy potential from forests in the EU

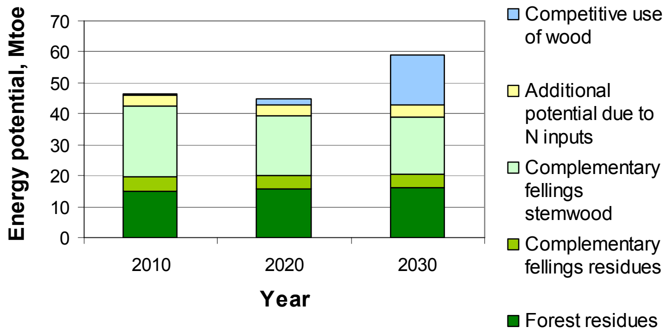


Note: Calculations cover EU-25 Member States without Cyprus, Greece, Luxembourg and Malta

([29]) The energy value of wood chips was assumed to be 64 EUR/m³ in 2020 and 94 EUR/m³ in 2030 (see Annex 3). If a higher oil price of EUR 50 per barrel was assumed, the potential being redirected from competing industries would increase to 6 and 33 MtOE in 2020 and 2030, respectively.

Bio-energy potentials from European forests

- harvest residues constitute an attractive potential for bio-energy
- increased harvest from “complementary fellings” more costly
- depending on future market price for energy, competitive use of wood increases



EEA bioenergy report, Main assumptions:

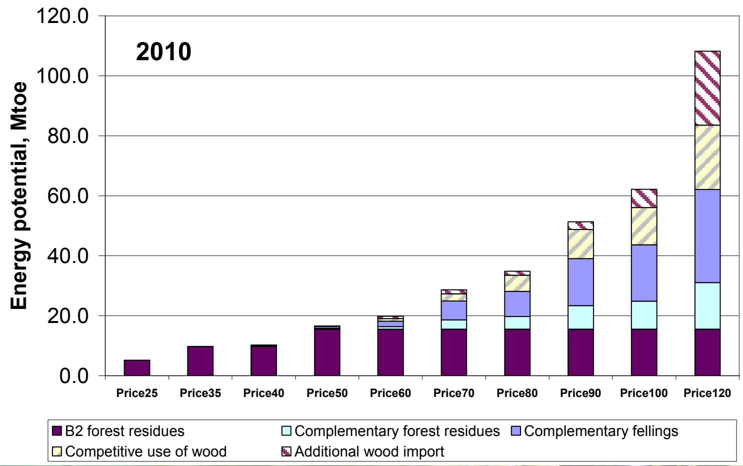
- The EU25 population is expected to almost stabilize between 2000 and 2030,
- GDP is expected to grow at an average 2,4% between 2000 and 2030,
- Oil price is assumed at a conservative low level of 35 € per barrel,
- CO2 permit is assumed 30 €/t of CO2 in 2020 and 65 €/t of CO2 in 2030,
- Oil price of 50 €/barrel is assumed in additional sensitivity scenario to reflect recent price increases.

Estimation of costs for residue extraction

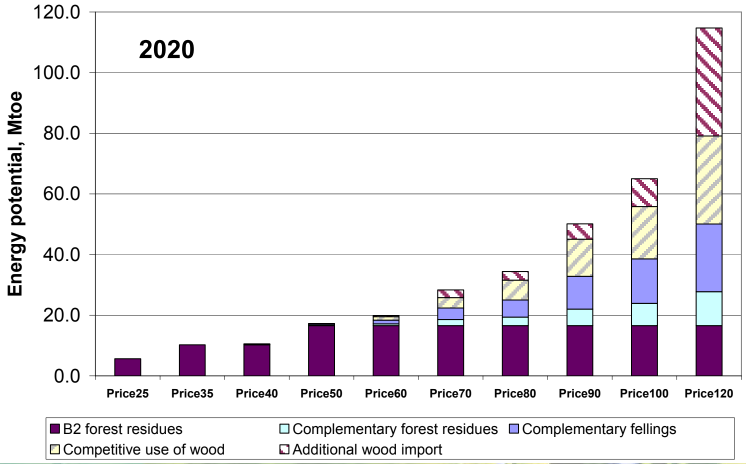
•Costs estimates for residue extraction were available from Finland and Germany.
•Finnish costs were applied also to Sweden
•German costs were assumed to be representative for EU-15 countries except for Sweden and Finland.
•For new member states, the costs were scaled down by 30 % because of lower salary levels.

	Non-coniferous residues	Coniferous residues
	EUR/m^3	EUR/m^3
Finland and Sweden	25	25
Rest of EU-15	35	53
EU-10 (new members)	25	35

Bioenergy potential from forest sector in the EU, 2010 (EFI-GTM scenarios)



Bioenergy potential from forest sector in the EU, 2020 (EFI-GTM scenarios)



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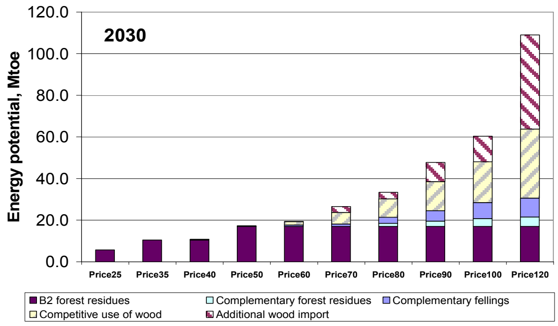
Bioenergy potential from forest sector in the EU, 2030 (EFI-GTM scenarios)



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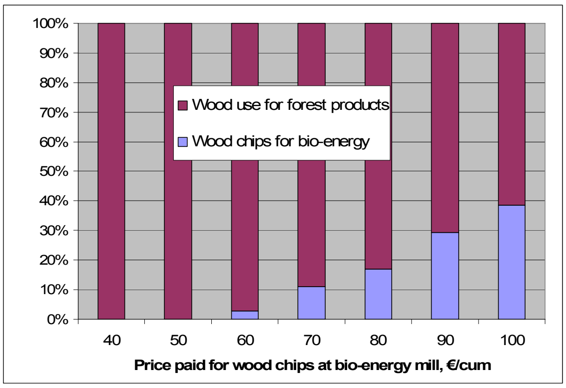
Competitive use of wood for bio-energy versus wood for forest products

- Increasing market values for bioenergy would lead to substantial mobilisation of wood biomass resources for bio-energy from other competing industries currently utilising wood resources.

- With a wood chip price of 70€/m^3, chemical pulp production in the EU might decline by around 10-15%.

- If the price for wood chips increases even higher to 100€/m^3, the reduction of chemical pulp production could be up to 50%.



Acknowledgement

Funding for this study was received from

- European Environment Agency's **European Topic Centre on Biological Diversity** / Project **Renewable energies potential and optimal use of biomass**
- EU FP6 project **MEACAP (Impact of Environmental Agreements on the CAP),** Contract No. 503604

Colleagues who contributed to the work in various ways:

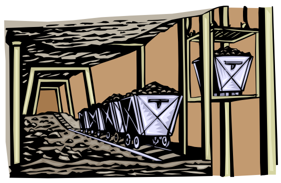
Torsten Tritscher, James Walmsley, Tim Green (all EFI); Tobias Wiesenthal, Aphrodite Mourelatou, Tor-Björn Larsson (all EEA); Claire Ruscassie (SOLAGRO)

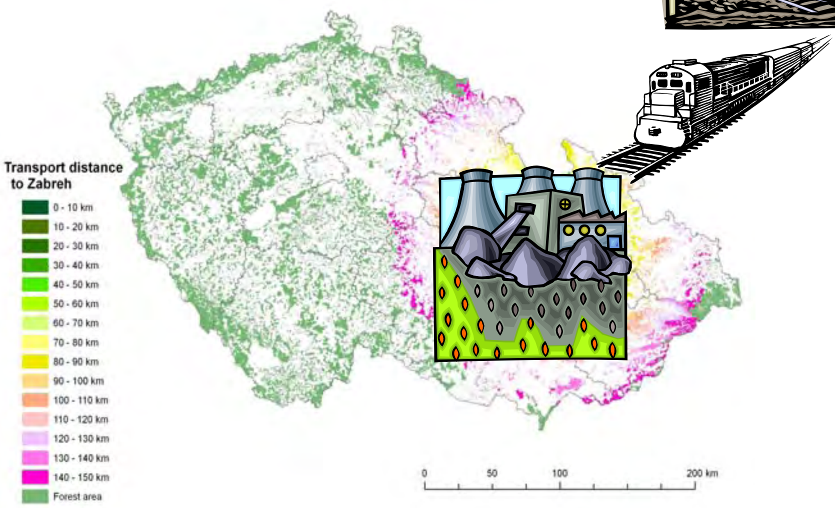
Metla method: Biomass resources, costs and constraints

Antti Asikainen, Timo Karjalainen, Harri Liiri, Juha Laitila, Sanna Peltola & Perttu Anttila METLA, Joensuu

EU Forest-based biomass for energy: cost/supply relations and constraints, 18-19 September 2007, Joensuu, Finland

Coal supply chain





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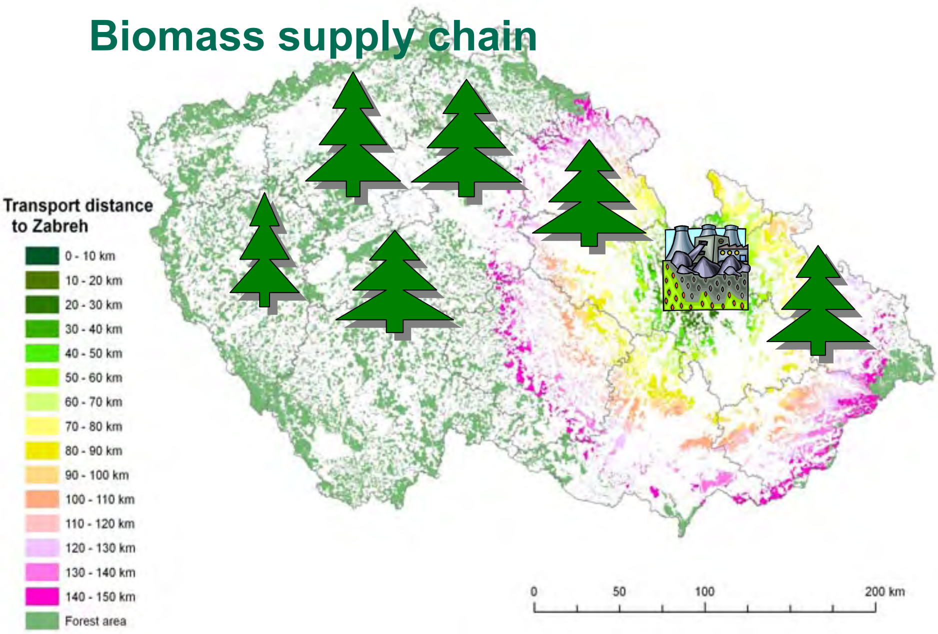
Biomass supply chain



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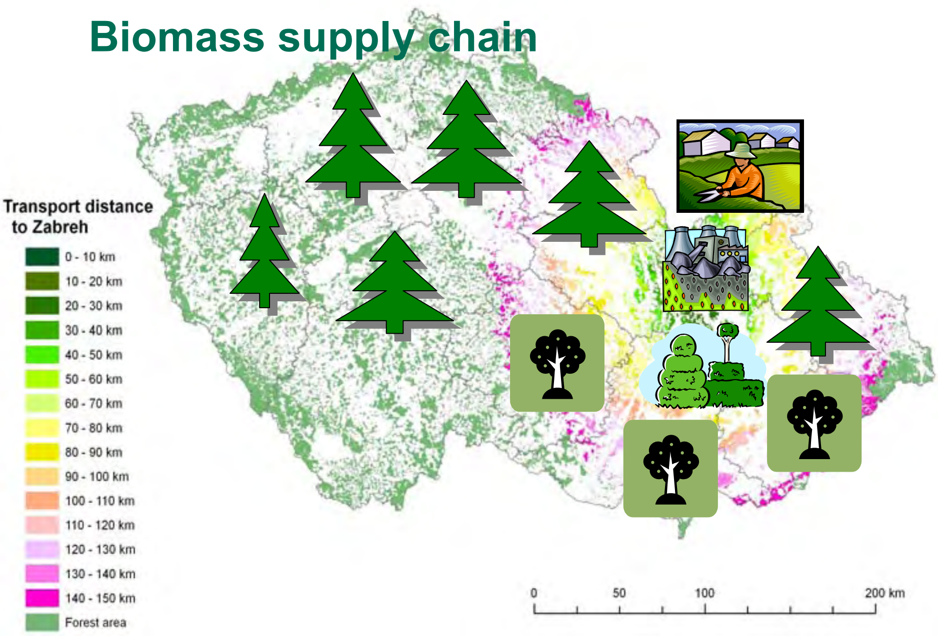
Biomass supply chain



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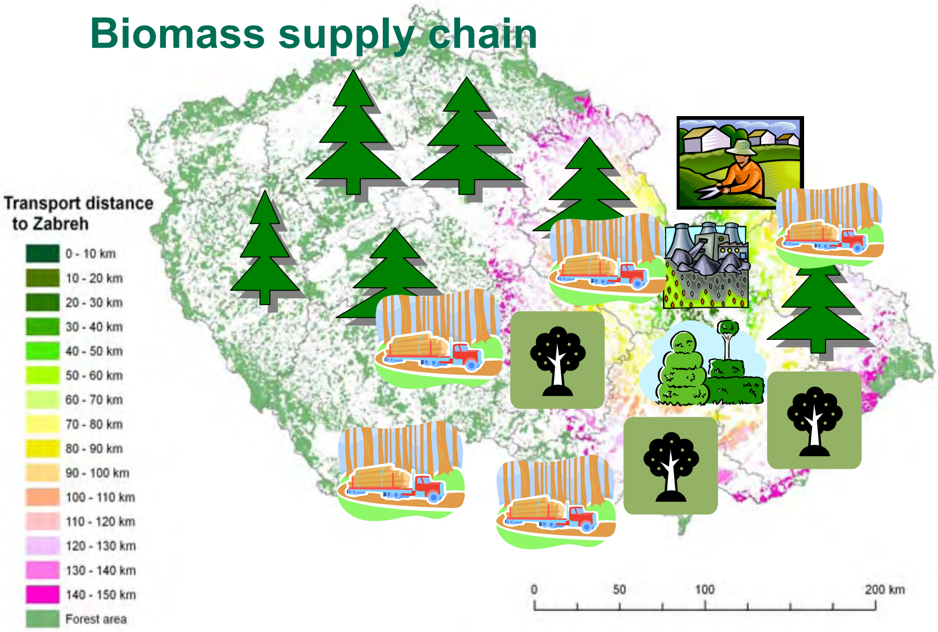
Biomass supply chain



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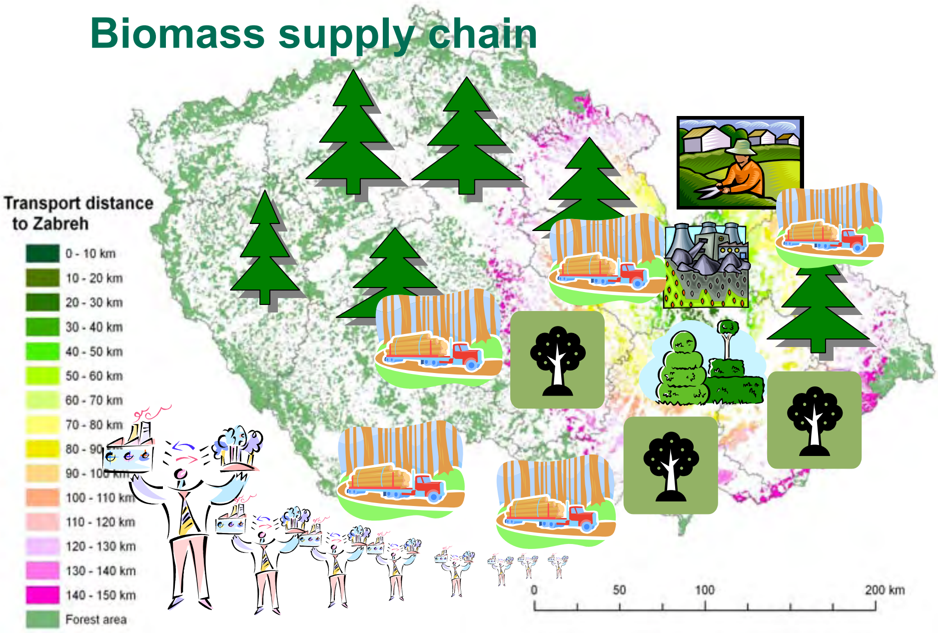
Biomass supply chain



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Contents

- Biomass resources of the EU 27:
  Sanna Peltola
- Estimation of Costs-supply curves
  Harri Liiri
- Impacts of competition
  Antti Asikainen

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Contents

- Biomass resources of the EU 27
- Costs and volumes of supply

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Forest biomass resources

- 1. Residues and stumps from current fellings

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Forest biomass resources

- 2. 25% of the balance (net growth-fellings)

Commercial growing stock, current fellings and balance (UN-ECE/FAO 2005)

Country	Commercial growing stock, million m³	Current fellings, million m³/y	Annual change rate	
			1990 – 2000 million m³	2000 – 2005 million m³
Austria	1 132	15.9	14.1	14.2
Belgium	172	3.8	2.94	2.98
Bulgaria	347	3.1	12.1	8.4
Cyprus	-	-	-	-
Czech Republic	712	16.3	7.37	7.36
Denmark	58	0.9	0.94	0.44
Estonia	419	7.5	-	-2.12
Finland	1 815	59.1	16.26	17.6
France	2 305	33.4	17.5	42.2
Germany	-	54.5	62.2	-
Greece	156	0.4	1.4	1.4
Hungary	329	3.8	3.716	2.367
Ireland	-	2.8	0.74	1.12
Italy	1 014	3.8	23.8	31.56
Latvia	511	10.6	9.5	10.6
Lithuania	344	5.9	5.27	5.4
Luxembourg	26	0.1	0.557	0
Malta	-	-	-	-
The Netherlands	52	0.9	0.9	0.8
Poland	1 760	31.7	25.12	25.66
Portugal	232	10.4	7.5	7.4
Romania	1 320	11.4	-0.11	0.180
Slovakia	418	6.4	6.16	6.24
Slovenia	326	2.6	6.122	4.532
Spain	689	15.7	19.8	19.6
Sweden	2 423	68.7	24.24	24.24
United Kingdom	300	8.6	4.2	6.4
TOTAL	16 860	378.3	272.3	238.6

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Estimating the shares of biomass components

- Proportions of biomass components used in the volume estimation. Above ground biomasses are based on equations presented by Marklund (1988) and volumes of stump and root estimates are based on Eggers (2001)

	Stem + Stembark	Stem wood loss	Branches	Needles	Tops	Total	Stump wood estimation (rest of Europe)	Stump wood estimation (Nordic and Baltic countries)
SPRUCE GROUP	55%	8%	24%	11%	2%	100%	19.1%	21.9%
PINE GROUP	67.7%	8%	17.7%	4.7%	2%	100%	19.3%	19.8%
BROADLEAVED GROUP	78.2%	8%	12.1%	/	1.7%	100%	14.7%	22.4%

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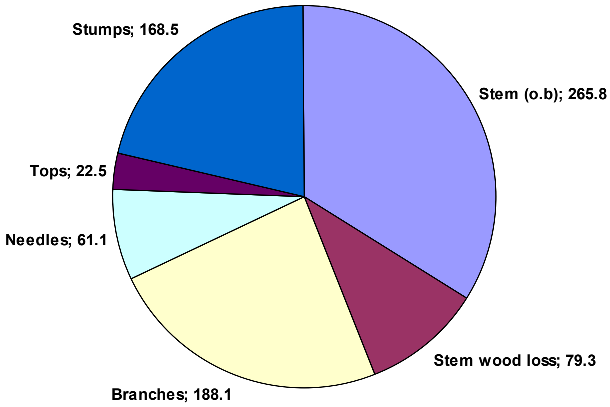
Theoretical forest fuel potential: 785 mill. m^3 (630 mill. t, 1 600 TWh)



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Reduction factors, current fellings

- 75% of final fellings and 45% thinnings harvestable
- recovery rates
  - 65% after harvester cutting
  - 55% after chainsaw cutting
- harvestable stumps
  - [33% - mountain% x 33%]

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Reduction factors, balance

- 25% of balance to energy production
- also roundwood to energy
- same reductions for stumps as for final fellings

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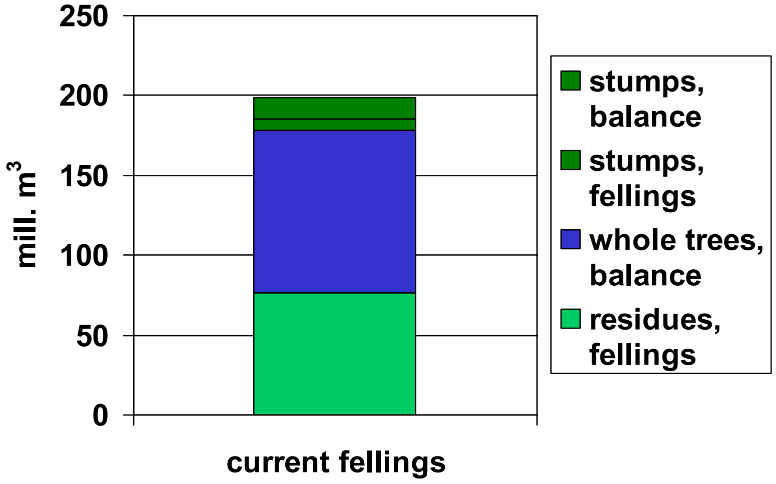
Volumes of available felling residues

	Share of timber from clearcuts %	Share of mechanization in cutting %	Total felling residues (mill. m^3/a)	Available Residues of felling (mill. m^3/a)	Available Residues of balance (mill. m^3/a)	Total vol. of stumps from fellings (mill. m^3/a)	Available vol. of stumps from fellings (mill. m^3/a)	Balance vol. of stumps (mill. m^3/a)
Austria	18 %	30 %	10.9	3.0	5.5	4.97	0.05	0.66
Belgium	70 %	80 %	2.2	0.9	1.1	1.06	0.12	0.13
Bulgaria	70 %	5 %	1.2	0.4	2.3	0.69	0.01	0.34
Cyprus	-	-	-	-	-	-	-	-
Czech Republic	83 %	40 %	11.2	4.4	3	5.17	0.66	0.34
Denmark	70 %	50 %	0.6	0.2	0.2	0.32	0.05	0.04
Estonia	73 %	70 %	3.8	1.4	0	2.42	0.18	0
Finland	71 %	97 %	35.7	15.3	6.3	20.04	2.11	0.95
France	76 %	40 %	16.9	6.4	14.2	8.93	0.53	1.85
Germany	5 %	35 %	32.8	8.4	22	16.02	0.11	2.83
Greece	-	-	-	-	-	-	-	-
Hungary	72 %	15 %	1.2	0.4	0.6	0.76	-	0.09
Ireland	82 %	95 %	2.1	0.9	0.4	0.93	0.17	0.05
Italy	20 %	2 %	1.3	0.3	9.5	0.80	0.002	1.22
Latvia	76 %	35 %	4.8	1.8	3.4	3.26	0.14	0.56
Lithuania	50 %	5 %	2.7	0.8	1.7	1.82	0.06	0.29
Luxembourg	70 %	80 %	0.1	0.03	0.2	0.03	0.003	0.02
Malta	-	-	-	-	-	-	-	-
The Netherlands	80 %	25 %	0.4	0.1	0.3	0.22	0.01	0.03
Poland	44 %	4 %	14.4	4.2	8.3	8.36	0.10	1.16
Portugal	70 %	30 %	3.8	1.4	2.2	2.37	-	0.31
Romania	70 %	1 %	5.6	1.8	0.1	2.85	0.16	0.01
Slovakia	40 %	4 %	3.4	1.0	2.1	1.69	0.04	0.27
Slovenia	0 %	6 %	1.5	0.3	1.5	0.72	-	0.2
Spain	70 %	40 %	6.1	2.3	6	3.81	-	0.85
Sweden	70 %	98 %	42.4	18.1	8.4	23.46	2.41	1.28
United Kingdom	80 %	90 %	5.7	2.5	2.3	2.71	0.31	0.3
		total	210.8	76.5	101.6	113.4	7.2	13.8

83.7+115.4 =199.1 million m³/year

Harvestable forest chips in EU27



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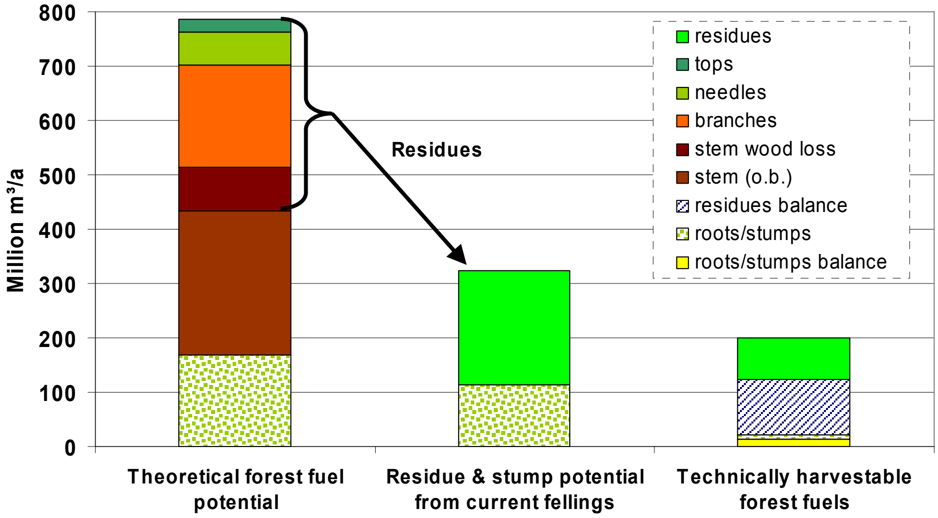
Harvestable forest chips in EU27



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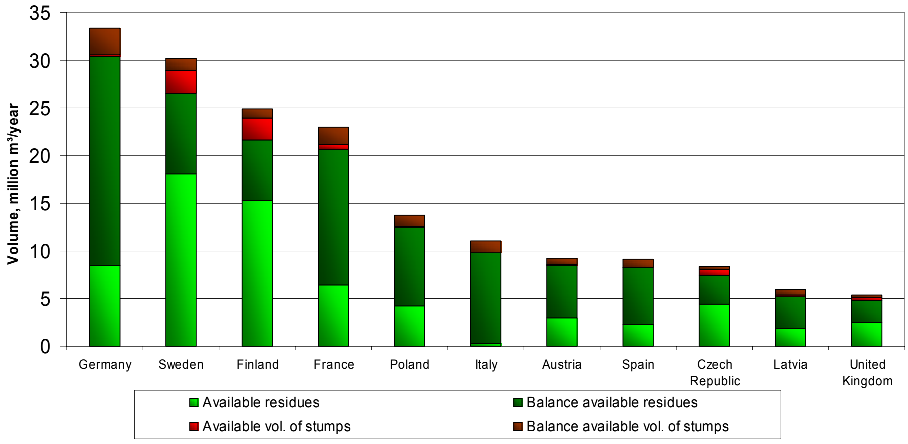
Forest biomass resources of EU27



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Estimation of the procurement costs for final felling residue chips

- Czech Republic, Finland, France, Hungary, Poland, Slovakia, Spain & UK
- Based on the total potential of the residues from the mechanized final fellings (restrictions)
- Availability of chips from felling residues in each country was expressed in terms of an annual availability of fuel (solid volume (m^3) of green biomass), around consumption point (e.g. power and district heating, DH, plant) at given marginal cost of fuel delivered at the plant.
- The harvesting costs of chips were calculated on the basis of logging residue chip procurement cost calculator, which was developed in the Finnish Forest Research Institute (J.Laitila).

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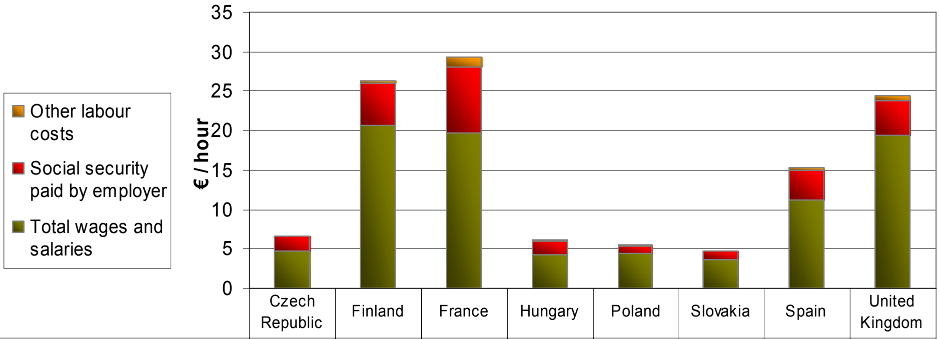
Structure of labour costs in 2005
(Eurostat)



	Czech Republic	Finland	France	Hungary	Poland	Slovakia	Spain	United Kingdom
Other labour costs	0.09	0.32	1.25	0.17	0.18	0.04	0.26	0.60
Social security paid by employer	1.74	5.45	8.40	1.68	0.92	1.14	3.79	4.50
Total wages and salaries	4.81	20.62	19.64	4.29	4.45	3.62	11.17	19.38

costs and fuel prices

	Forwarder	Chipper	Truck/trailer
Purchase price, €	242 000	400 000	240 000
Operating hours	2026	2700	3000
Service time, years	8	8	5.1/7.7
Depreciation rate, %	22	20	-
Interest rate, %	6	6	5

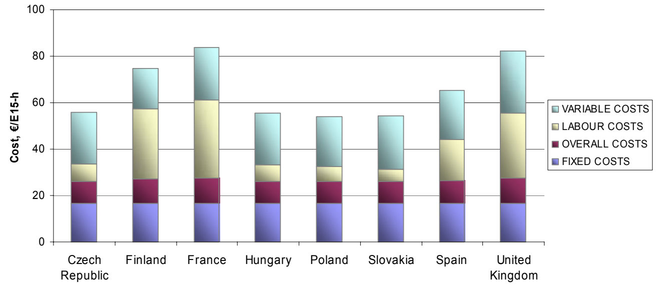
	Forwarder €/hour	Chipper €/hour	Transporting driving €/h	Transporting loading/unloading €/h
Czech Republic	55.86	123.83	77.1	34.5
Finland	74.56	128.54	106.0	63.4
France	83.81	154.53	110.53	66.81
Hungary	55.39	123.90	76.8	33.8
Poland	54.03	119.71	74.17	32.91
Slovakia	54.52	126.34	76.97	31.85
Spain	65.16	128.48	86.22	46.70
United Kingdom	82.27	171.86	115.59	59.98

Liquid fuels consumer prices €/litre (including taxes)
15.12.2006

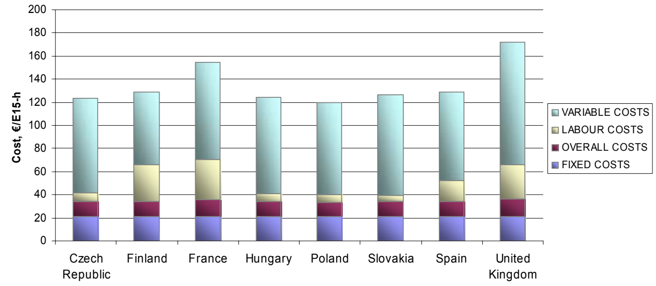
	Diesel oil	Fuel oil / Heating oil
Czech Republic	1	
Finland	1	0.58
France	1.03	
Hungary	1.01	
Poland	0.96	
Slovakia	1.07	
Spain	0.91	
United Kingdom	1.37	

Hourly costs of a …

forwarder



chipper



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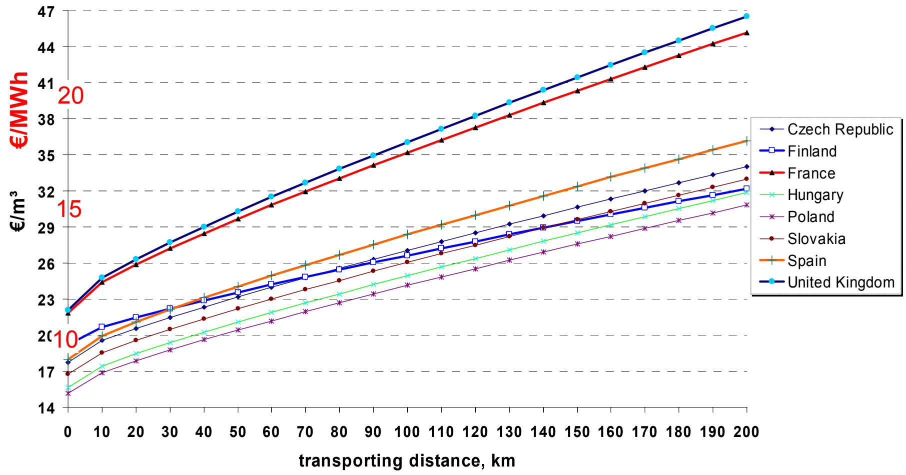
Costs of chips delivered at plant from final fellings



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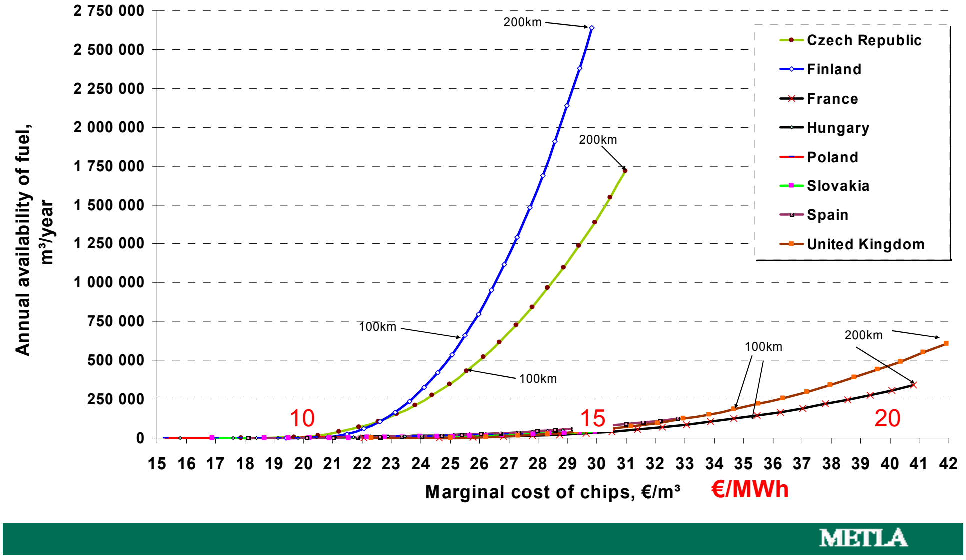
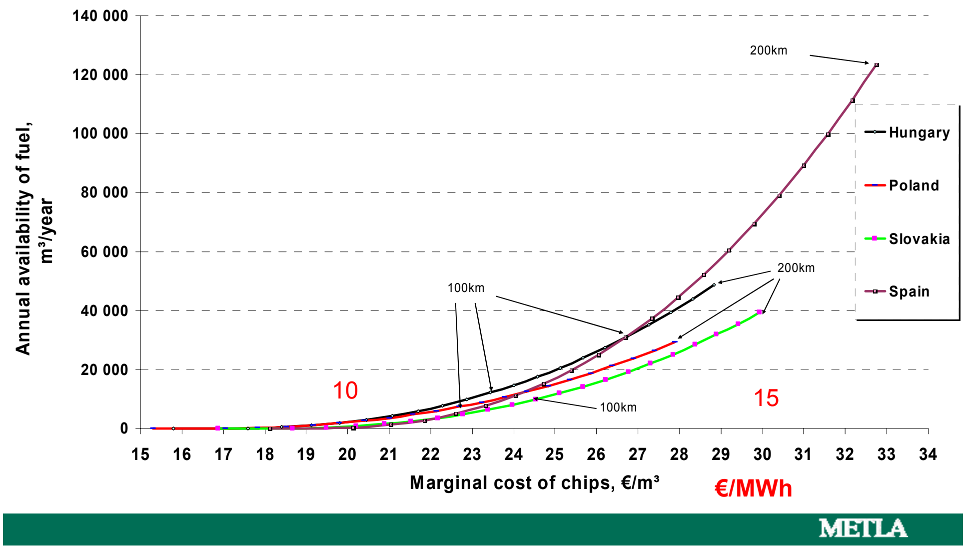
Costs of chips delivered at plant from final fellings



Costs of chips delivered at plant from final fellings



Availability of felling residue chips at given prices (delivered as chips at mill) and availability of felling residues from procurement areas with the radius (defined as the distance along the road network) of 100 and 200 km.

	Avail. residues at 10€/MWh (20€/m³) 1000 m³	Avail. residues at 15€/MWh (30€/m³) 1000 m³	Avail. residues at radius of 100 km 1000 m³	Avail. residues at max radius of 200 km 1000 m³	Cost range €/m³		
Czech Republic	9.3	1548	429	1715	17.88	-	30.97
Finland	2.7	over max radius	660	2639	19.40	-	29.82
France	-	35.2	85	341	22.05	-	40.80
Hungary	2.3	over max radius	12	49	15.80	-	28.83
Poland	2.1	over max radius	7	30	15.30	-	27.89
Slovakia	0.7	over max radius	10	40	16.88	-	29.94
Spain	0.3	72.6	31	123	18.11	-	32.74
United Kingdom	-	50.4	152	608	22.30	-	41.91

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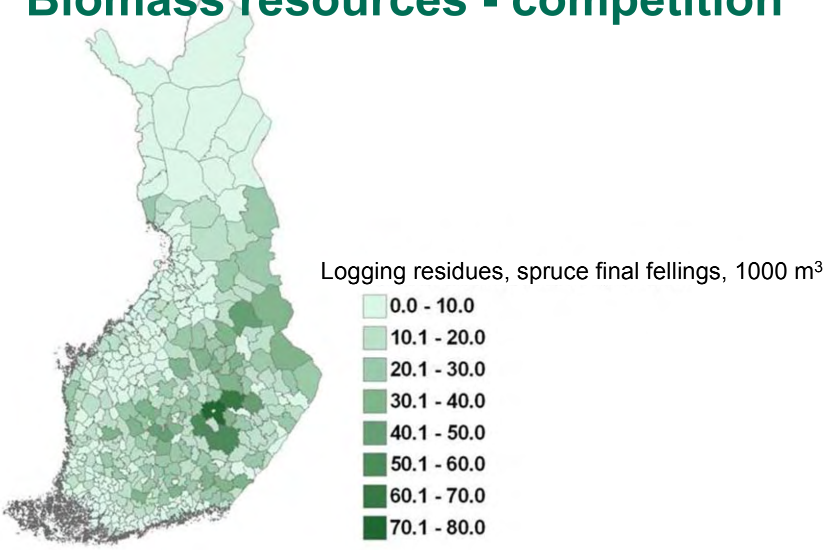
Biomass resources - competition



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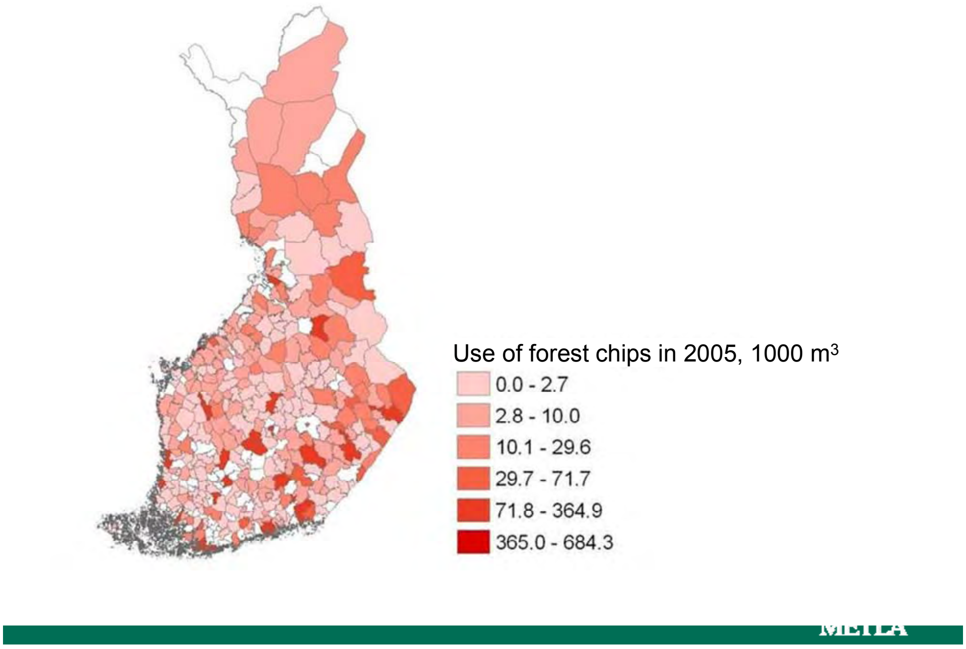
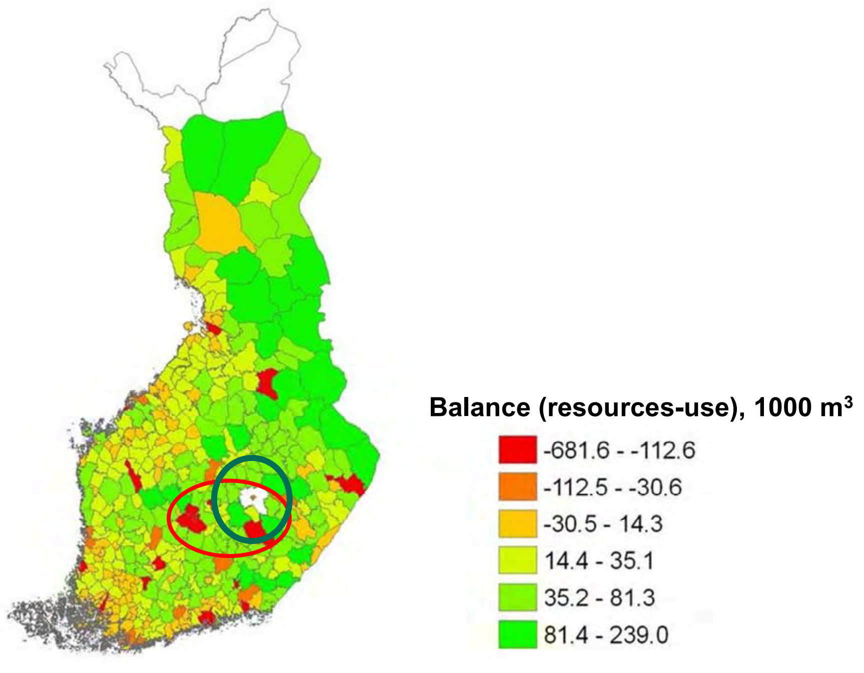
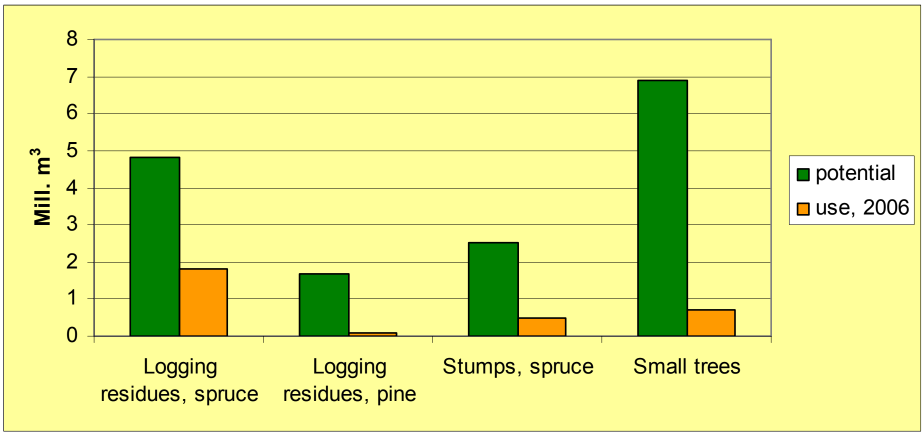
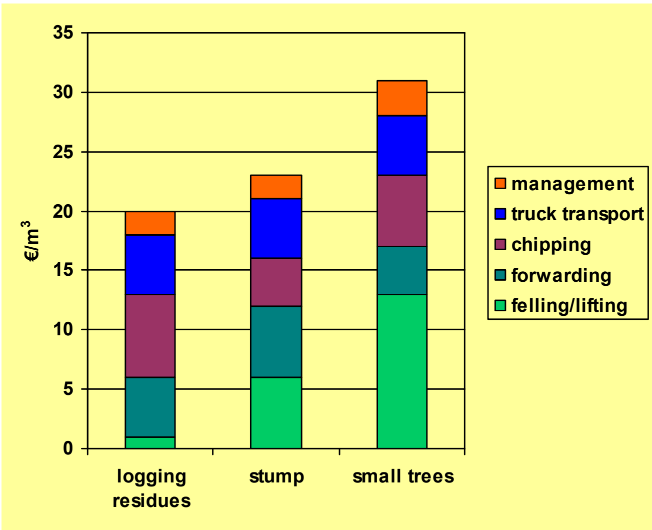

Use of forest chips in 2005, 1000 m3
0.0 - 2.7
2.8 - 10.0
10.1 - 29.6
29.7 - 71.7
71.8 - 364.9
365.0 - 684.3
METLA


Balance (resources-use), 1000 m3
-681.6 - -112.6
-112.5 - -30.6
-30.5 - 14.3
14.4 - 35.1
35.2 - 81.3
81.4 - 239.0



Competition: Increase potential is in small trees

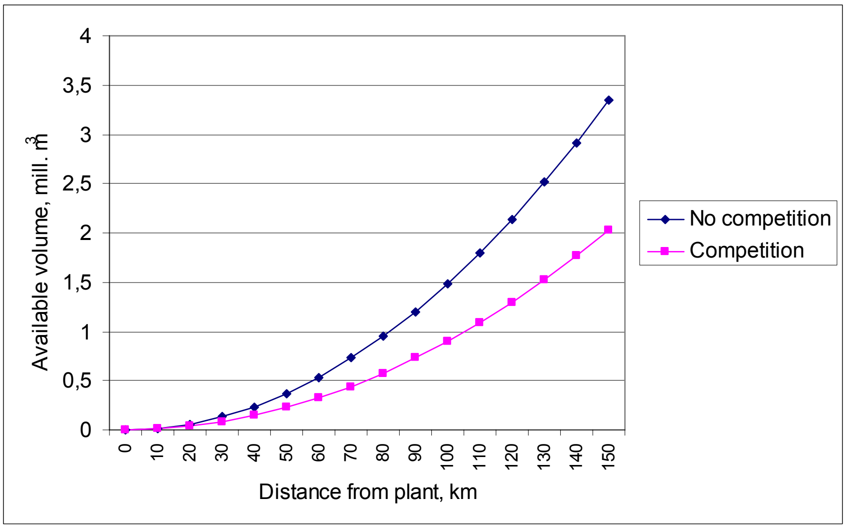


Impacts of competition

- Increasing cost of supply
- Systems with effective long distance transport capacity become competitive
- New resources (stumps) have buffered the cost effect

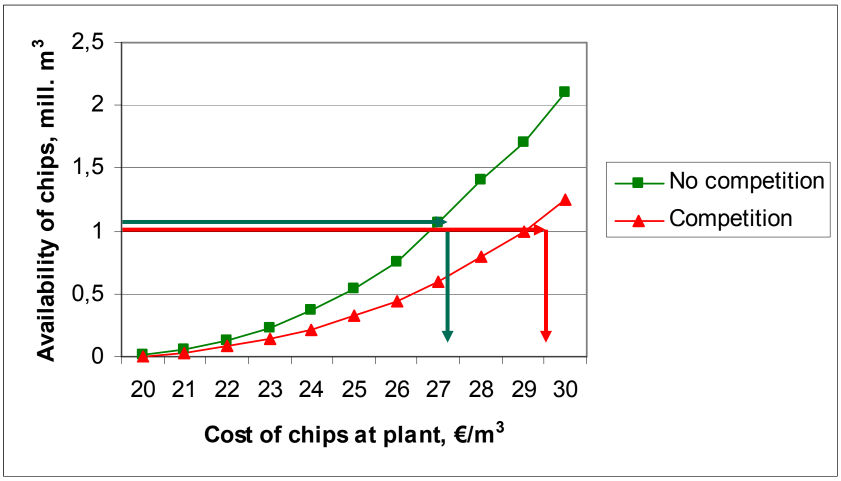
METLA

Impacts of competition, Central Finland



METLA

Impacts of competition, Central Finland



METLA

Concluding remarks

- Forest biomass supply running already in most EU -countries
  - transfer of technology
  - tailoring of technology
- Competition on biomass increases costs and procurement areas
  - effective harvesting and long distance transport logistics must be developed

METLA

Biomass for Bioenergy
Potentials for Production and Supply

Expert Consultation

"EU Forest-based biomass for energy: cost/supply relations and constraints"

18-19 September 2007, Joensuu, Finland

Florian Kraxner

Georg Kindermann, Sylvain Leduc, Michael Obersteiner, Uwe Schneider, Dmitry Rokityanskiy, Martin Kuehmaier, et al.

IIASA
Science for Global Insight

Overview

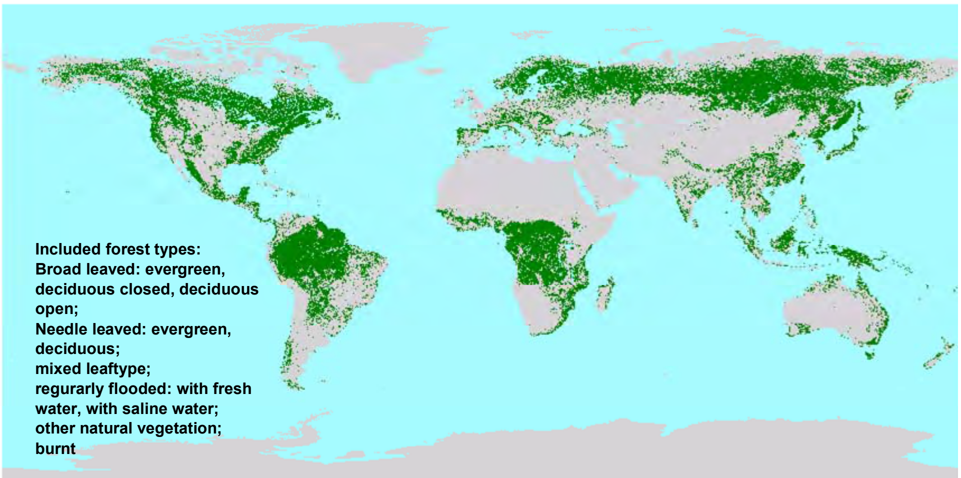
- **Global** Prediction of Biomass Production
- **Global** Bioenergy Supply Potentials
- **EU** Prediction of Biomass Production
- **Regional** Prediction of Biomass Production
- **Siting and Scaling** of Biomass Power Plants
- **Transport Costs** for Biomass
- **Harvesting Costs** for Biomass
- **Market Interactions** for Bioenergy

Results of the global Model

- Actual Energy consumption: 420 PJ
- Production in Forests: 1300 PJ
- Production in managed Forests: 640 PJ

- Harvest losses
- Sawn-wood use
- Energy Input for Planting and Harvest

Forest (cover) map, GLC2000



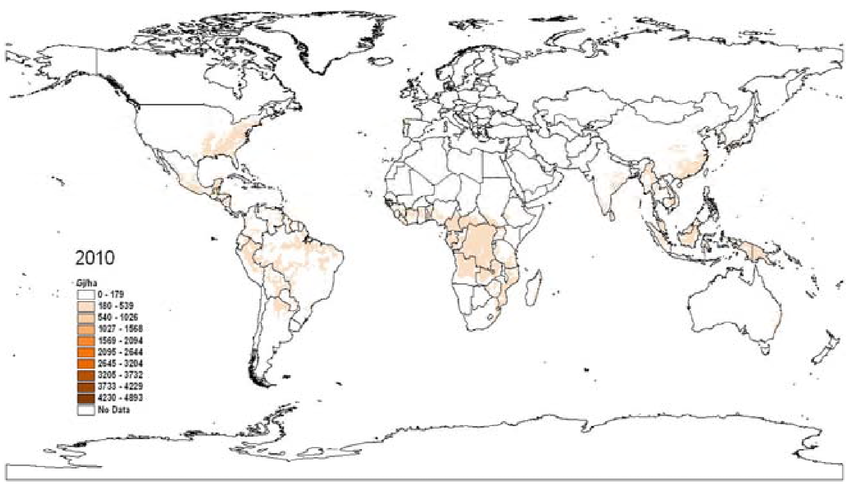
Source:
Bartholomé, E. and Belward, A.S. 2005. GLC2000: a new approach to global land cover mapping from Earth Observation data. International Journal of Remote Sensing, Vol. 26 (9), 1959 - 1977.
and
Fritz, S., Bartolomé, E., Belward, A., Hartley, A., Stibig H.J., Eva, H., Mayaux, P., Bartalev, S., Latifovic, R., Kolmert, S., Roy, P., Agrawal, S., Bingfang, W., Wenting, X., Ledwith, M., Pekel, F.J., Giri, C., Mücher, S., de Badts, E., Tateishi, R., Champeaux, J-L., Defourny, P. (2003). Harmonisation, mosaicing and production of the Global Land Cover 2000 database (Beta Version), Luxembourg: Office for Official Publications of the European Communities, EUR 20849 EN, 41 pp., ISBN 92-894-6332-5.

Net Primary Production (NPP) Map

Areas with a high increment have a high net primary productivity and are indicated by dark green. Sites with low productivity are indicated by light green.

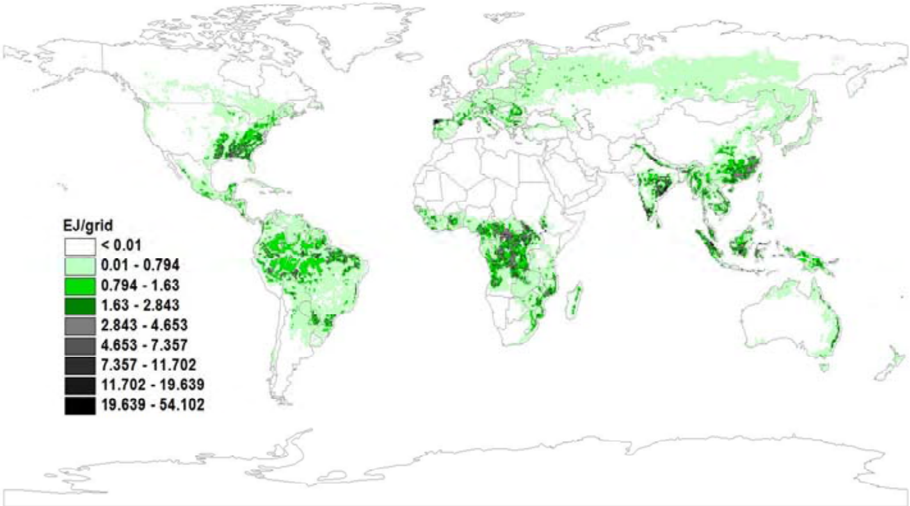
Kindermann *et al. Carbon Balance and Management* 2006 **1**:15 doi:10.1186/1750-0680-1-15, Derived from *Cramer and Field (1999)*

Bioenergy Supply for 2000-2100 B1 (Price < 6$/GJ)



Source: Rokityanskiy et al. 2006

Cumulative biomass production (EJ/grid) for bioenergy between 2000 and 2100 at the energy price supplied by MESSAGE based on the revised IPCC SRES A2r scenario (country investment risk excluded).

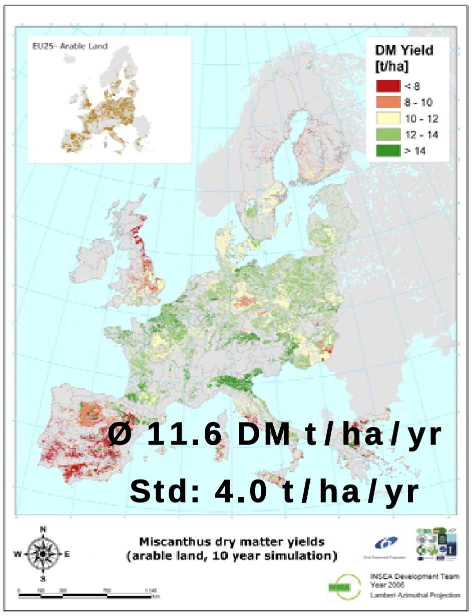


Source: Rokityanskiy et al. 2006

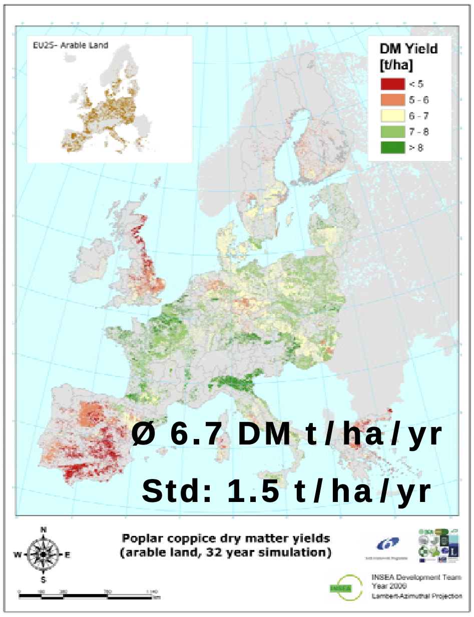
Alternatives

biomass

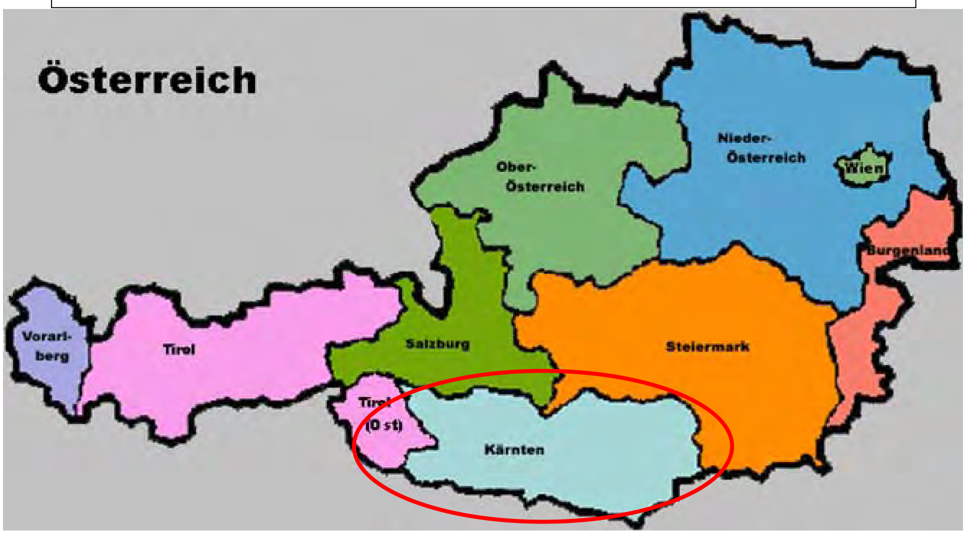
miscanthus



poplar coppice



Regional Biomass Predictions for Carinthia



Facts on the Province of Carinthia

- Size: 950 000 ha
- Inhabitants: 559 000
- Wood-Volume: 324 m³/ha
- Increment: 9.8 m³/ha/Year
- Harvest: 5.5 m³/ha/Year
- Forest cover: 60%
- Production: 40 000 GJ/Year
- Consumption: 88 000 GJ/Year

Results for Carinthia

- Energy Consumption: 88 000 GJ/Year
- Maximum harvestable Amount: 40 000 GJ/Year
- Realistic potential: 10 000 GJ/Year
- Current harvest: 2 500 GJ/Year

Biomass supply
Costs for Baden-Württemberg

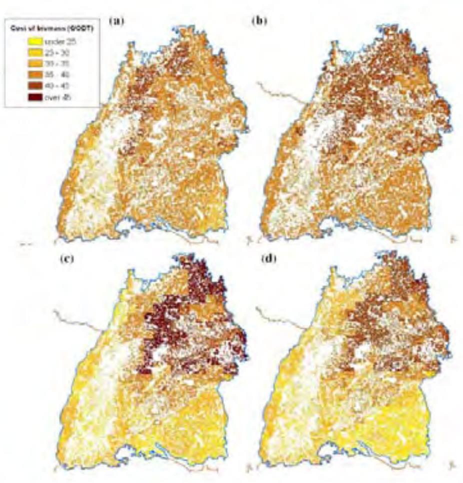
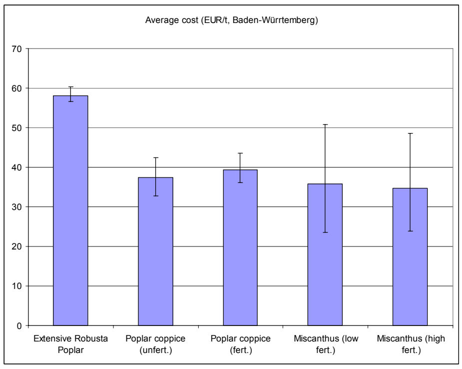
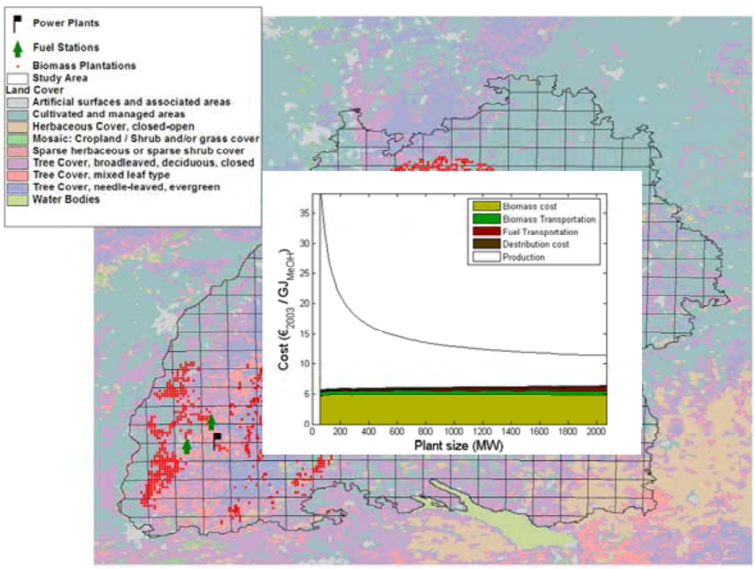


Figure 12: A comparison of estimated costs for biomass in different areas using different management options: (a) unfertilized poplar coppice,(b) poplar coppice fertilized with slurry, (c) miscanthus with lower fertilization, and (d) miscanthus with higher fertilization.



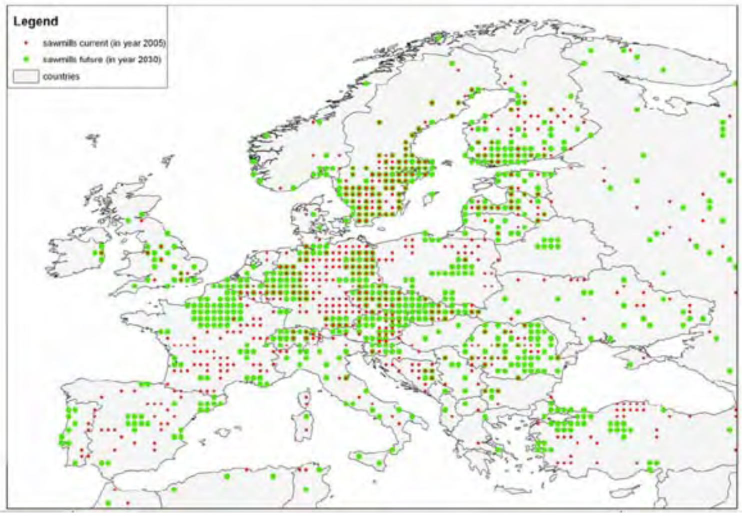
Source: Neuvonen, 2005

Methanol from Poplar
10% Car Fleet, 8,3% Arable Land, 25ha Plantation / 100ha



Source: Leduc et al. 2006

Results of spatial model: sawmills



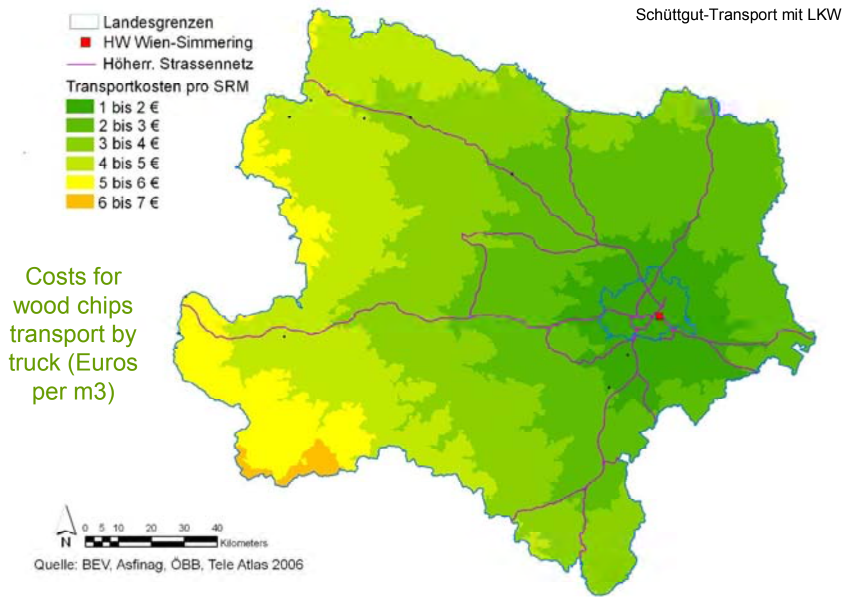
Geographic explicit distribution of current and potential future major sawmills in Europe (2005, 2030) , Source: Leduc et al., 2007

Biomass Power Plant Vienna / Simmering

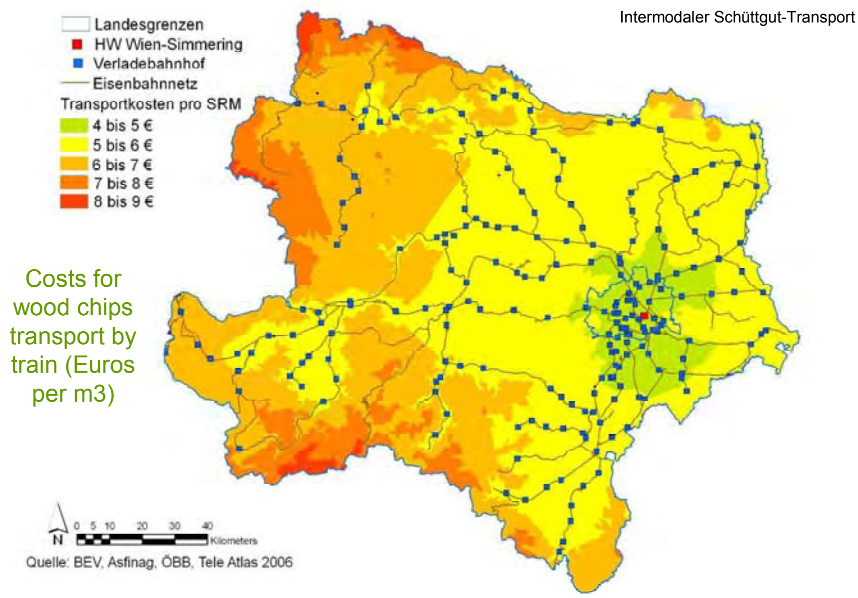
- **Project Planning**: Start: 2001, Grid: 2006
- **Type of Plant**: <u>Forest</u> Biomass Power Plant
- **Technology:** Combined Heat and Power Generation (CHP)
- **Capacity**: 65MW, 12-48,000HH

- **Consortium**:

WIEN ENERGIE WIENSTROM
WIEN ENERGIE FERNWÄRME WIEN
ÖBf ÖSTERREICHISCHE BUNDESFORSTE AG



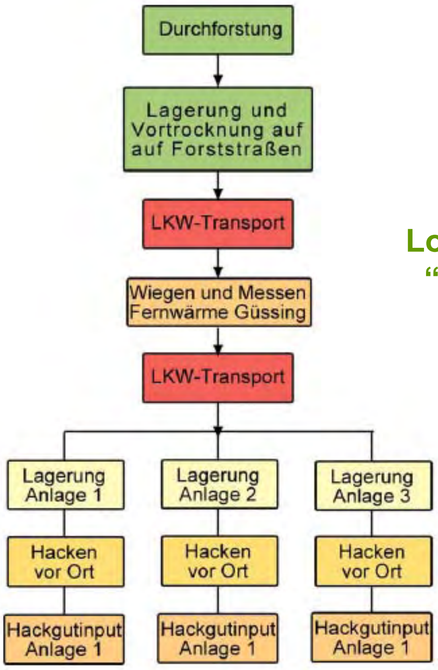
Kühmaier M. et al. (2007): Wertschöpfungskette Waldhackgut. Optimierung von Ernte, Transport und Logistik. Projektstudie im Auftrag von BMLFUW, Land Niederösterreich, Stadt Wien und ÖBf AG. Institut für Forsttechnik, Departement für Wald und Bodenwissenschaften, Universität für Bodenkultur, Wien.



Kühmaier M. et al. (2007): Wertschöpfungskette Waldhackgut. Optimierung von Ernte, Transport und Logistik. Projektstudie im Auftrag von BMLFUW, Land Niederösterreich, Stadt Wien und ÖBf AG. Institut für Forsttechnik, Departement für Wald und Bodenwissenschaften, Universität für Bodenkultur, Wien.

Guessing

Haupteinzugsgebiet der Holzressourcen im Bezirk Güssing (eigener Entwurf)



Logistic chain “Guessing”

Harvest and wood costs

Transport to chipping place

Chipping

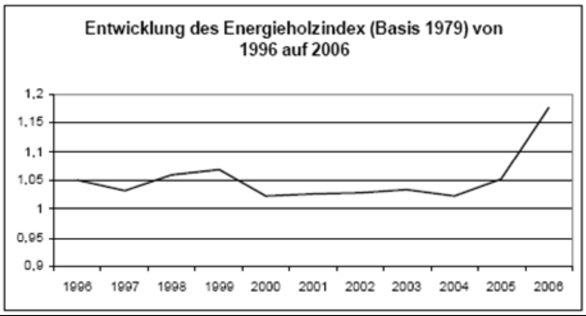
Transport to plant

Storage

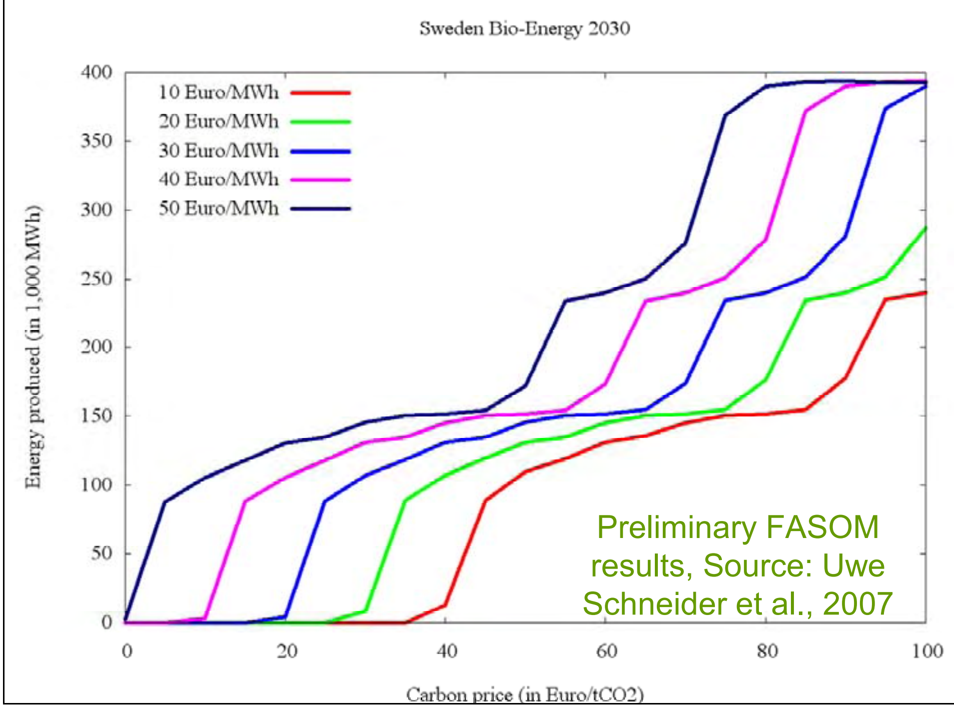
Aktuelle Brennstofflogistik Biomassekraftwerk Güssing			
Logistikkomponente	€/fm	€/Srm	€/t
Holzernte + Stockzins	20,60	8,24	20,19
Transport zum Hacker	7,58	3,03	7,43
Hacken	6,77	2,71	6,63
Transport Hackgut Energiezentrale	2,53	1,01	2,48
Bevorratung Hackgut Energiezentrale	0,11	0,04	0,11
Summe Logistikkosten	**37,59**	**15,04**	**36,84**
Logistik frei Werk	**37,48**	**14,99**	**36,73**

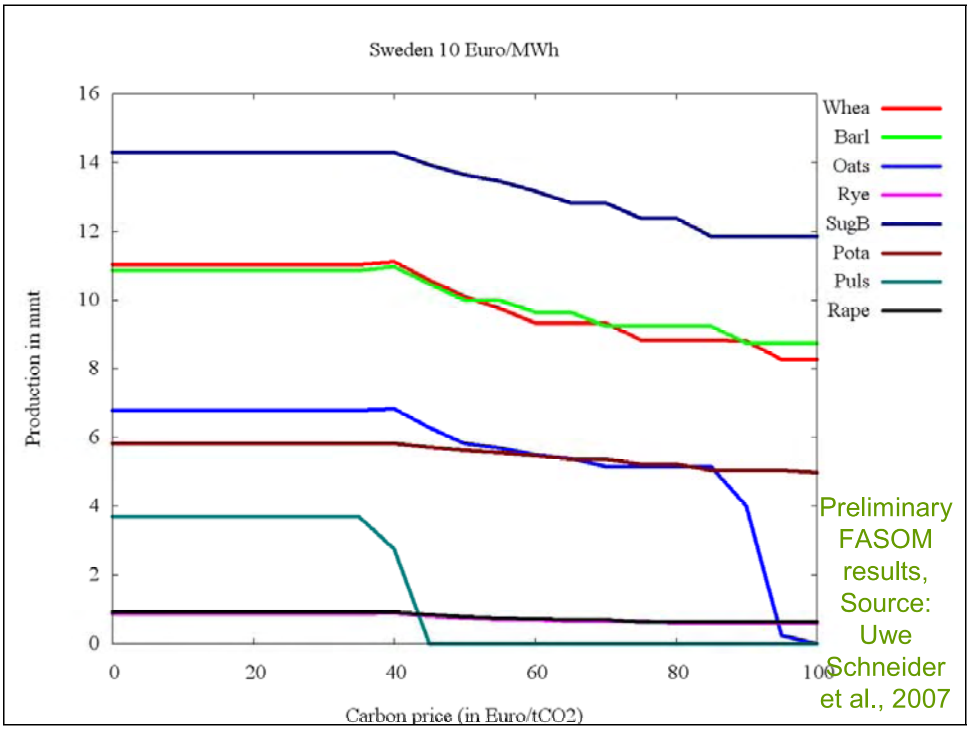
Energy wood logistics Güssing (Quelle: eigene Erhebungen)

Market Interactions

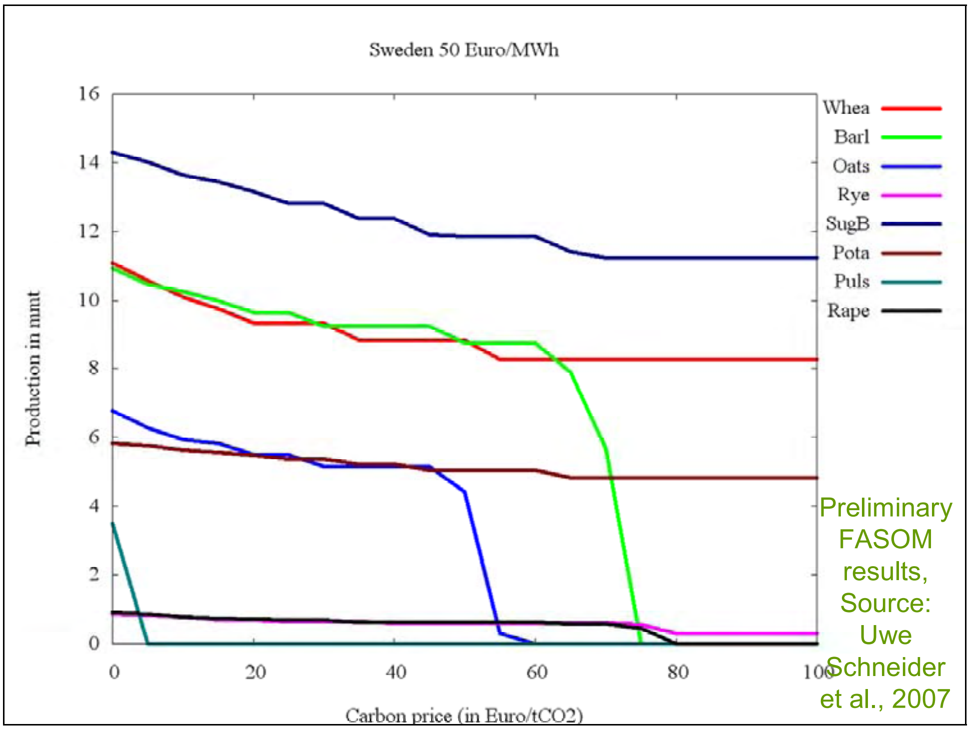


Source: BMLF 2007





Sweden 10 Euro/MWh
Production in mmt
Carbon price (in Euro/tCO2)
Whea
Barl
Oats
Rye
SugB
Pota
Puls
Rape
Preliminary FASOM results, Source: Uwe Schneider et al., 2007



Sweden 50 Euro/MWh
Production in mmt
Carbon price (in Euro/tCO2)
Whea
Barl
Oats
Rye
SugB
Pota
Puls
Rape
Preliminary FASOM results, Source: Uwe Schneider et al., 2007

LULEÅ UNIVERSITY OF TECHNOLOGY

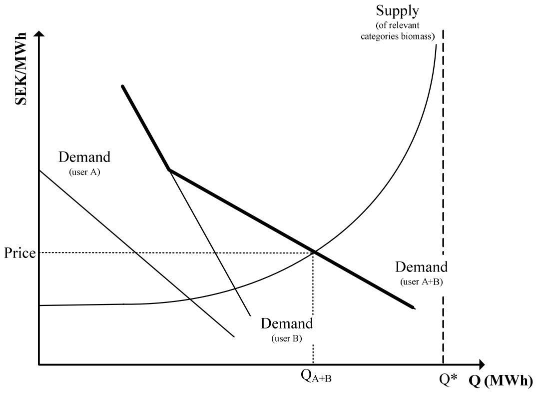
Cost-supply curves and bioenergy

Robert Lundmark

The northernmost University of Technology in Scandinavia
Top-class Research and Education

LULEÅ UNIVERSITY OF TECHNOLOGY

Schematic illustration of increased competition



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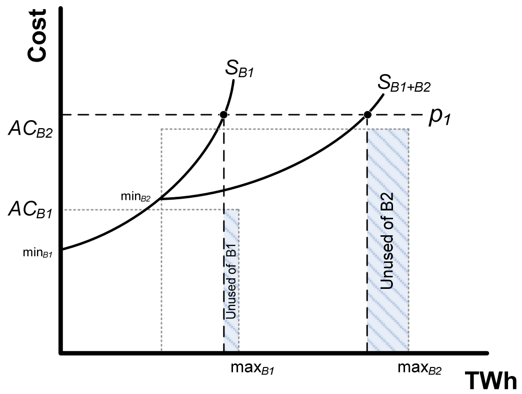
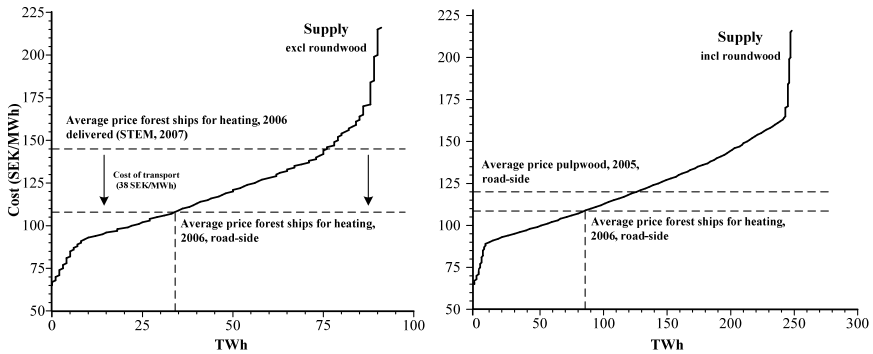
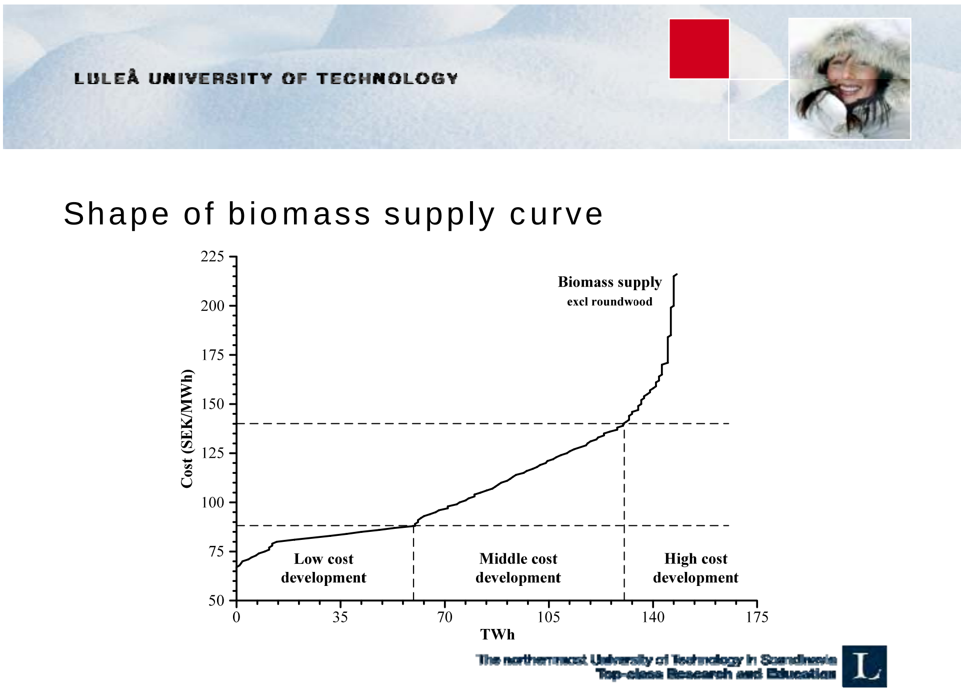
Problem using constant AC (and MC)



Supply using increasing MC





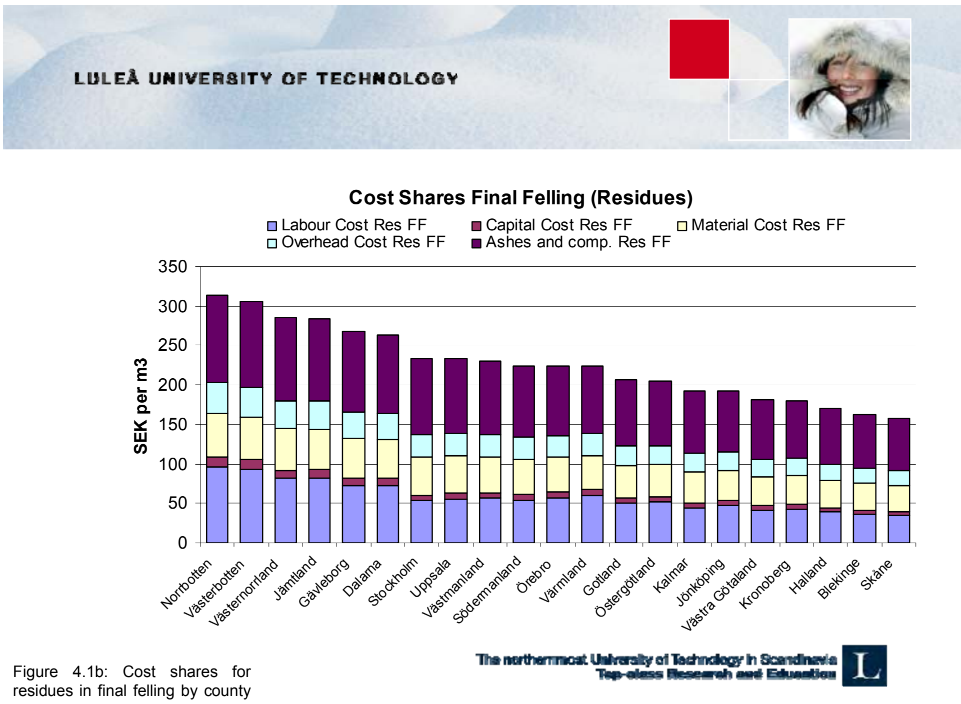


Figure 4.1b: Cost shares for residues in final felling by county and cost component.

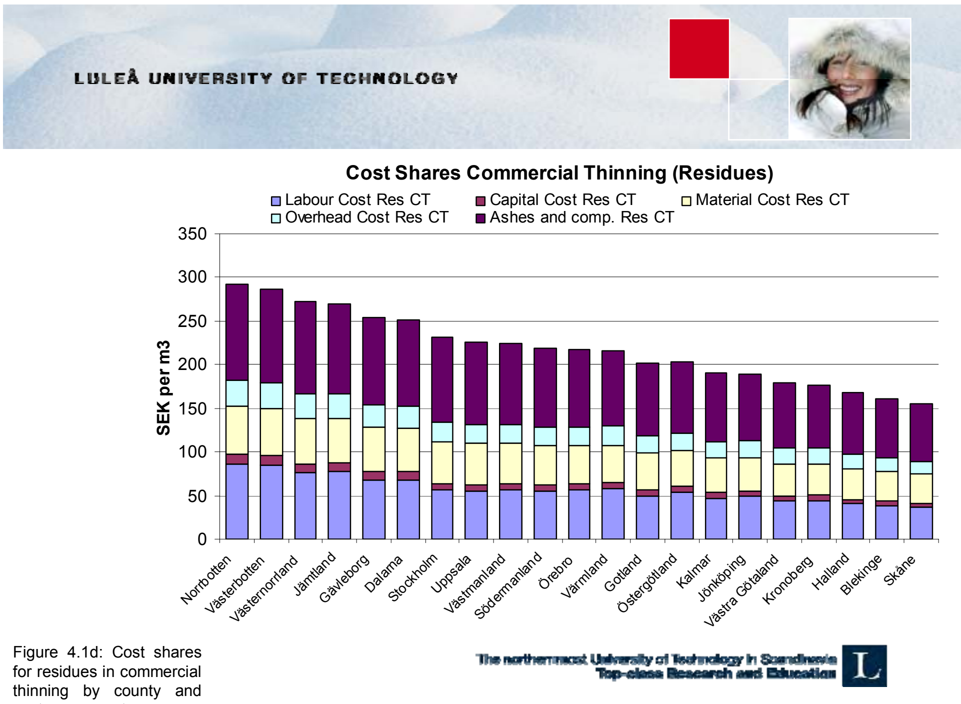


Figure 4.1d: Cost shares for residues in commercial thinning by county and cost component.

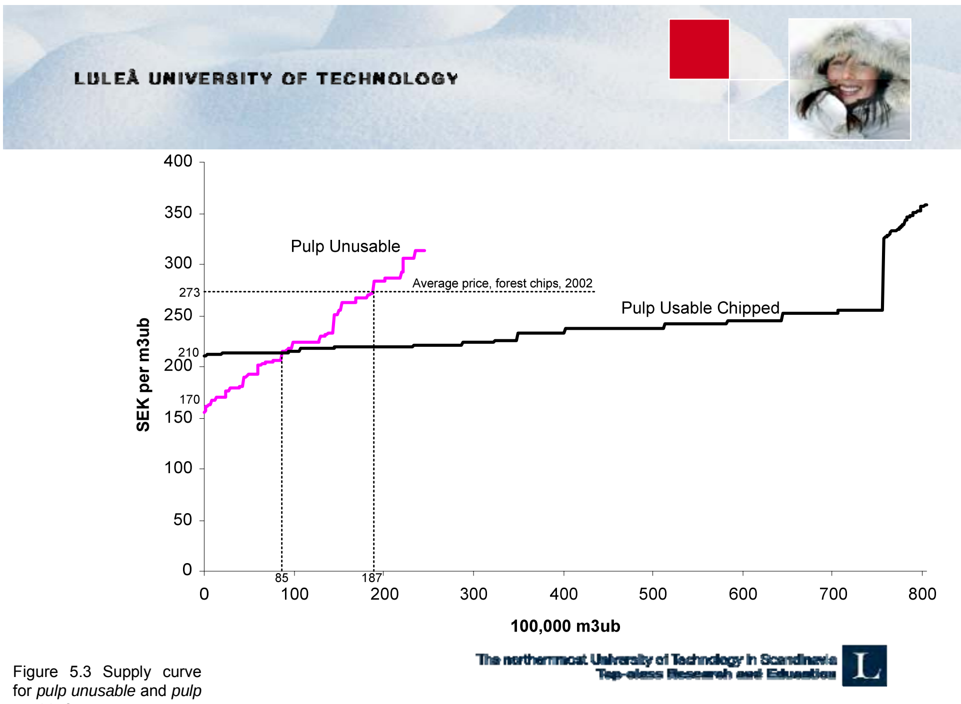
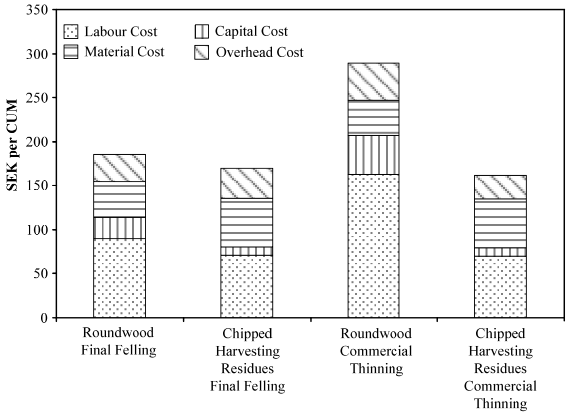


Figure 5.3 Supply curve for *pulp unusable* and *pulp usable* forest resources.

Cost shares



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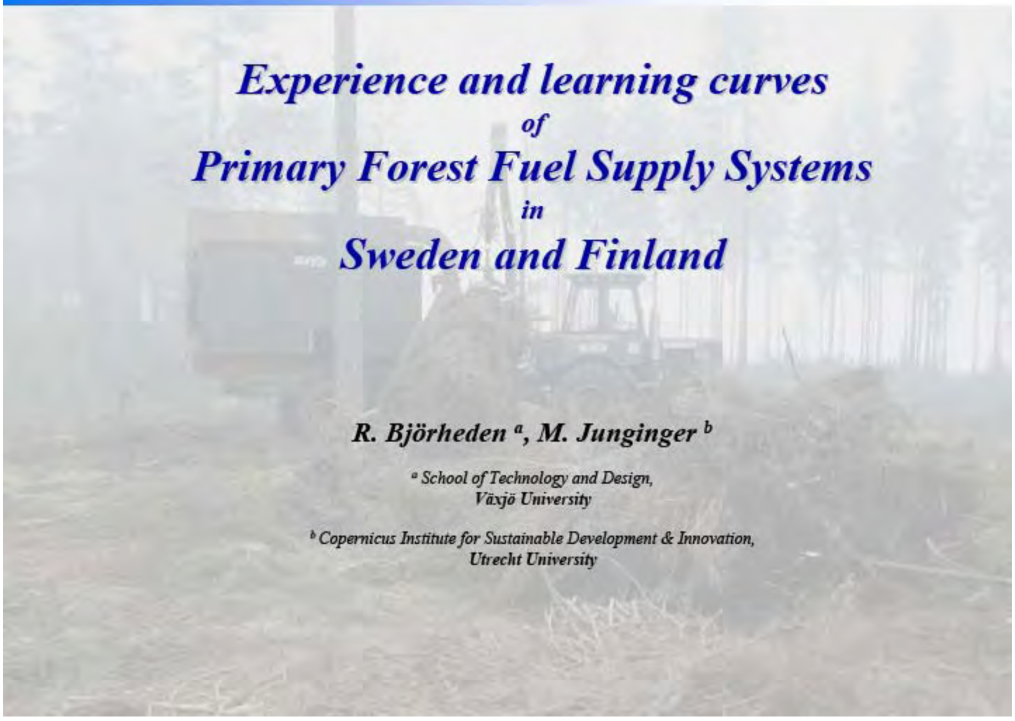
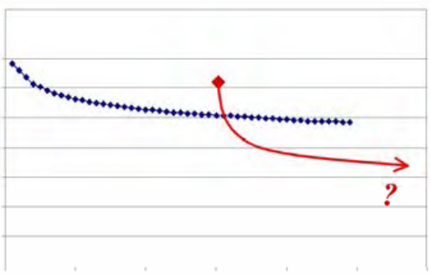


Introduction of new technologies …



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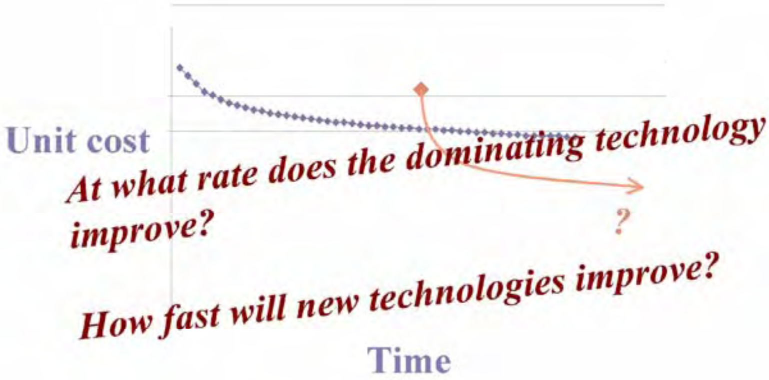
Introduction of new technologies …



At what rate does the dominating technology improve?

How fast will new technologies improve?

Experience and learning curves

C_{Cum}	$= C_0\, Cum^b$	(1)
$\log C_{Cum}$	$= \log C_0 + b \log Cum$	(2)
PR	$= 2^b$	(3)

C_{Cum} :Cost per unit

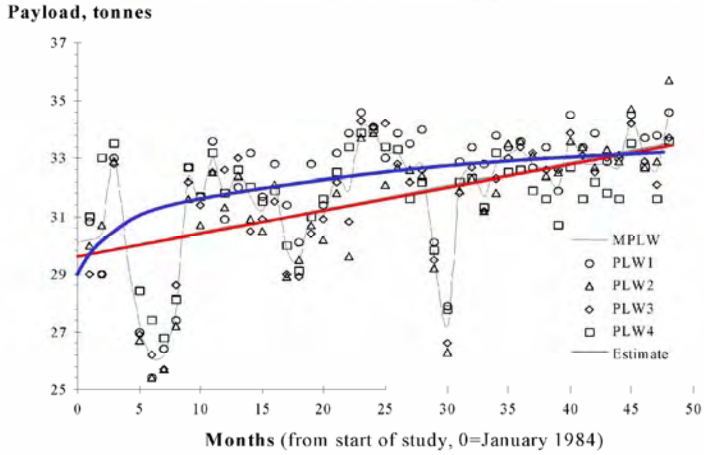
C_0 :Cost of the first unit produced

Cum :Cumulative (unit) production

b :Experience index (<0)

PR :Progress ratio

Productivity development of tree section hauling, Jan 84-Dec 88



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Productivity development of tree section hauling, excl climatic effects

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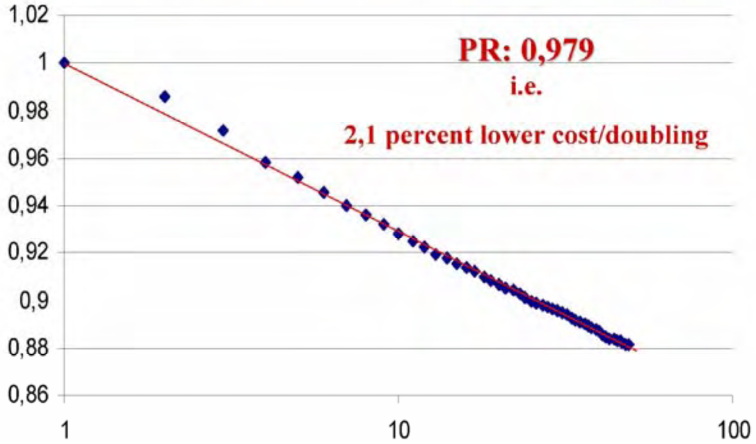
Did the learning curve compute OK?



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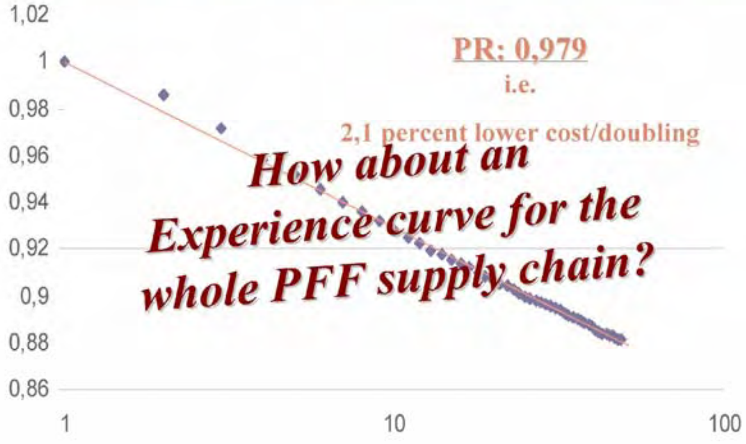
Did the learning curve compute OK?



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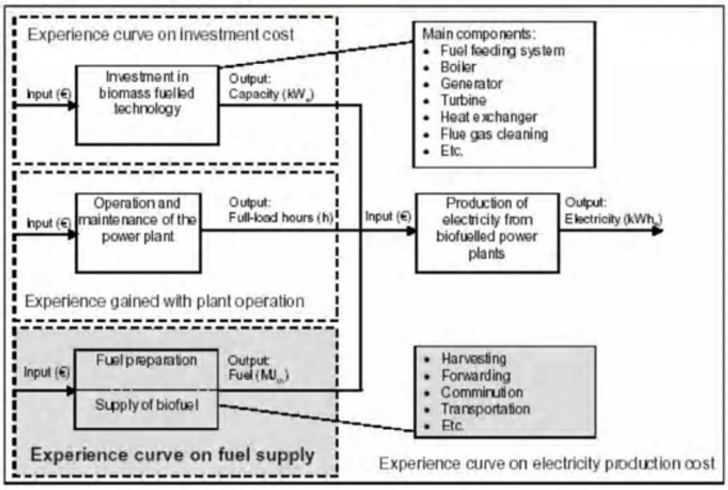
PFF supply chains



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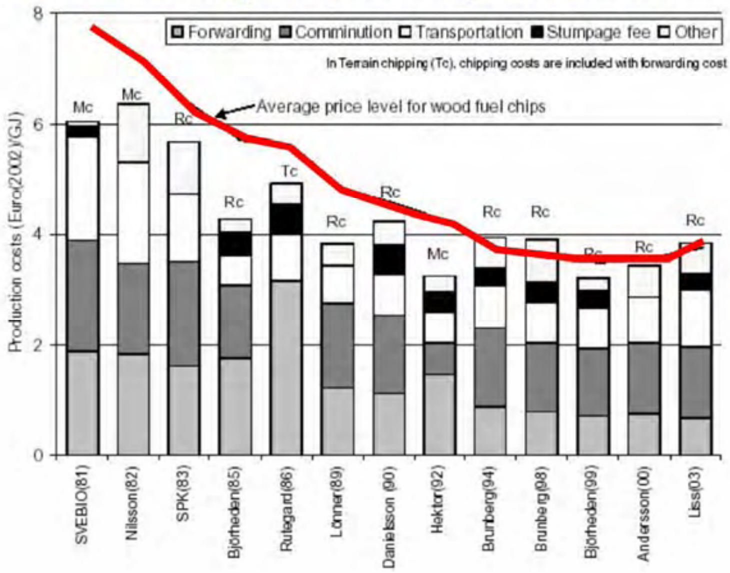
…cost and productivity data …



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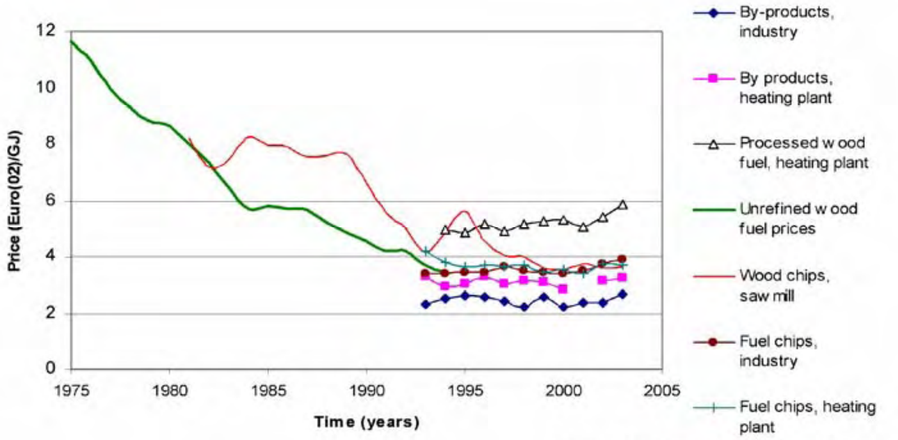
Swedish wood fuel prices



Sources: Hillring (various), National Energy Agency 2003

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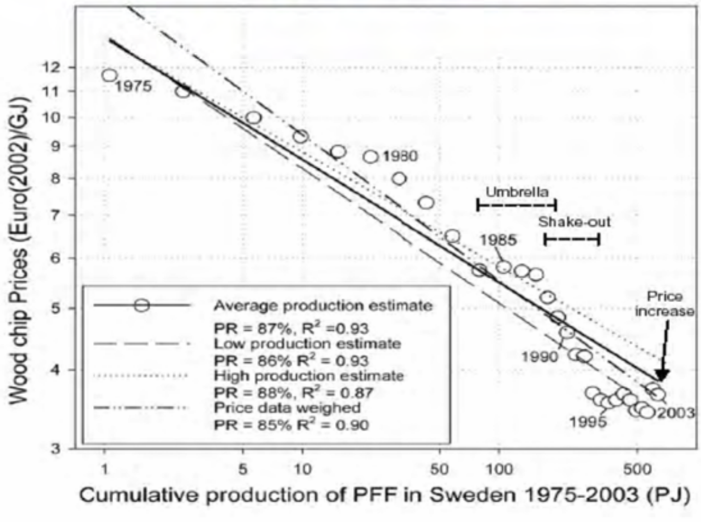
… checking hypothesis …



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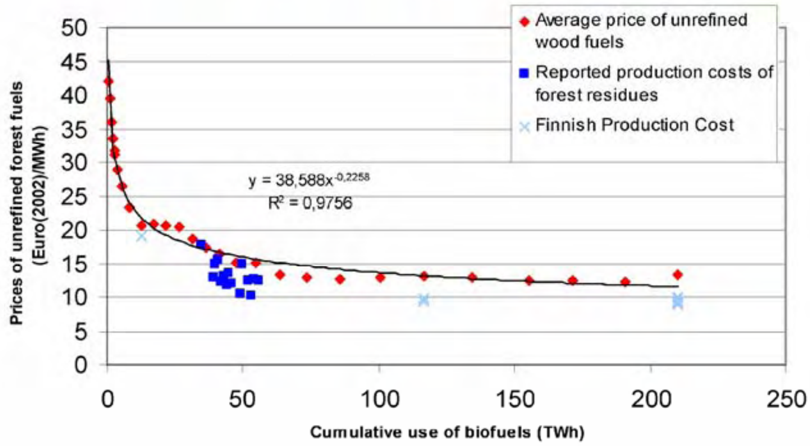
Cost reduction for forest fuels



Source: M.Junginger, working material 2004

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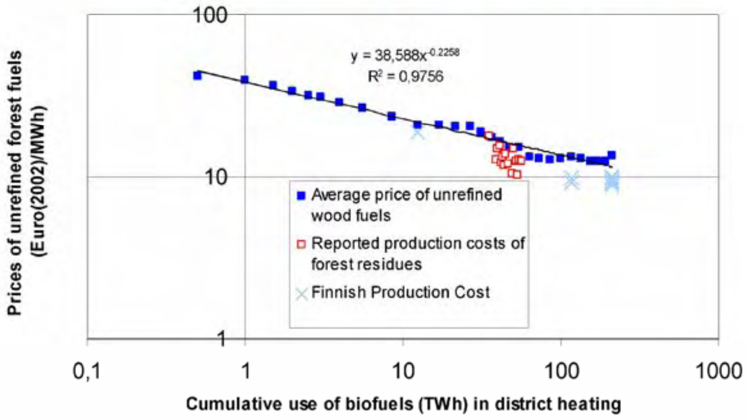
Cost reduction for forest fuels



Source: M.Junginger, working material 2004

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Conclusions

- Production costs decrease regularly with cumulative production
- Experience curve concept is suitable to describe this
- In Sweden, 1975-2003 for nine cumulative doublings of PFF production. PR is 85 - 88%, for Finland around 88-90%.
- Short to medium term, the experience curve may be a tool to assess further production cost development in Sweden

- A methodological issue is how learning took place between Sweden and Finland

- Monitor the cost developments of PFF production and to determine the necessary policy support measures for PFF production accordingly.
- Transferring knowledge and technology to other countries may be crucial to low PFF costs e.g within the frame of the growing Eastern European market and the emerging international trade in wood fuels.

The experience in energy from forest biomass in Catalonia- Spain

Joensuu, 18th- 19th 2007

Workshop “EU Forest-based biomass for energy: cost/supply relations and constraints”

Judit Rodríguez
Forest harvesting and biomass Team
Catalonian Forest Technology Center (CTFC)

Situation

Some steps in forest bioenergy availability assessments in Catalonia

- 2000-2001: Study for Energy Plan in Catalonia, developed by CREAF & CTFC.
- Objectives:
  - Forest biomass availability
  - Cost of forest biomass supply
- Base for more actual feasibility studies:
  - 5Eures IEE project
  - Enersilva Interreg project

Environmental and technical restrictions

- Coverage > 70 %
- Slope < 60%
- This restrictions lead to a **72%** of the forest area exclussion
- Excluded small diameter Oak wood, because of fire wood use at this moment
- Only not protected areas (2001)

Results of Roundwood balance

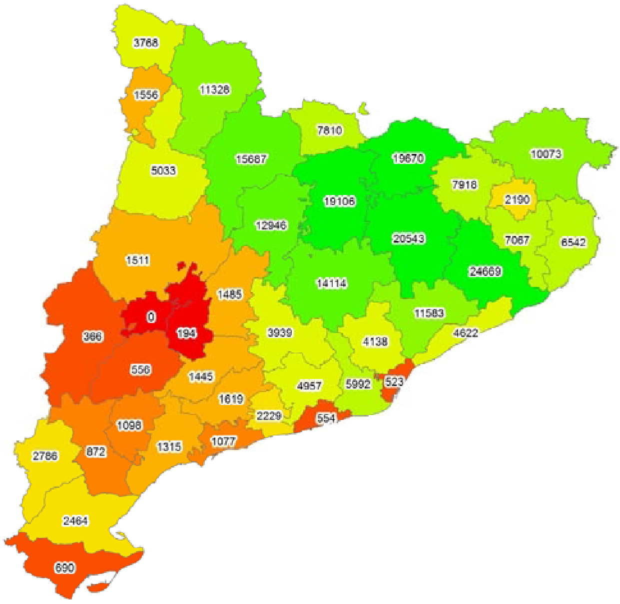
Available total biomass (not stump) (t p.s.e./any)			Available forest "residual" and (t p.s.e./any)		
Short term	Sustainable	(Fellings)	Short term	Sustainable	(Fellings)
644,348	1,044,213	422,755	246,034	274,380	88,013
%/TB -	-	-	38.2	26.3	20.8

How much can be harvested?

- 2 scenarios were supposed:
  - **Short-term availability:** harvesting surplus now, supposed to stabilize forests, and harvest some of the actual biomass accumulation in the forests
  - **Sustainable availability**: harvesting the anual increase of the forests

- *Aerial residual biomass:* top & branches, small trees from thinnings

Aerial forest biomass availability I, short-medium term scenary (o.d.t/year)



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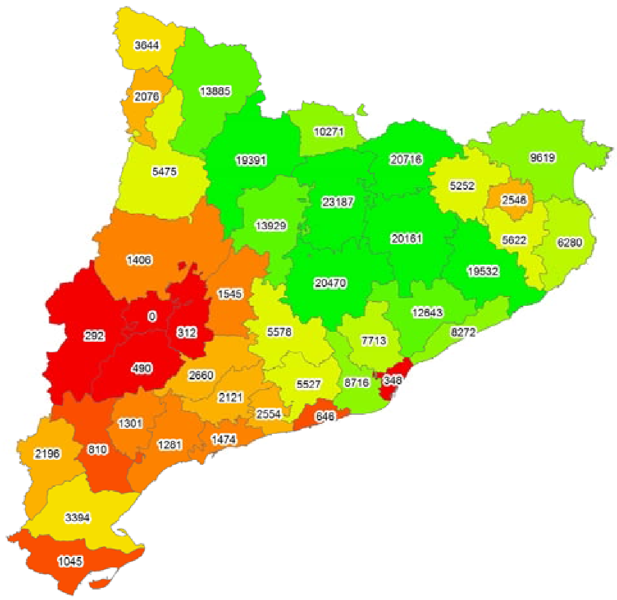
Forest harvesting and biomass
Catalonian Forest Technology Center

Aerial forest biomass availability II, sustainable scenary (o.d.t/year)

- Small trees and branches



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Some other constraints

- Not intensive forest harvesting activity, limited possibilities of enlarging forest supply chains (labour man lack, forest enterprise scattered)
- Forest road network limitations

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Forest harvesting and biomass
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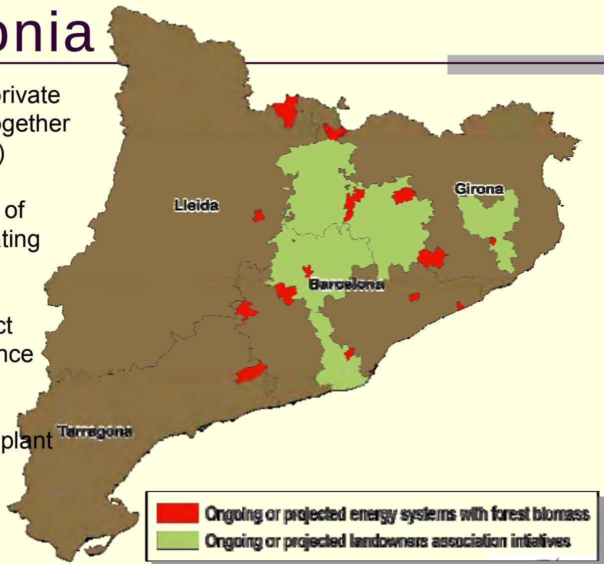
Current situation in Catalonia

5 counties where private owners will work together (cooperatives, etc.)

Undefined number of pellet and chip heating projects

An important district heating ongoing since 1992

One 5-7 MW CHP plant projected



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Some facts in Spain & Cat

- Oak wood (small wood) is almost completely used for fuel wood
- Some CHP forest biomass plants are ongoing. Foreseed some more 5-10 MW ones.
- New subsidies for biomass electricity production (RD 661/2007)
- Particle board industry disagree of using forest bioenergy. In Catalonia also special concern of all forest industry because of palette sawmill possibility of using small wood (until 15-10 cm diameter).

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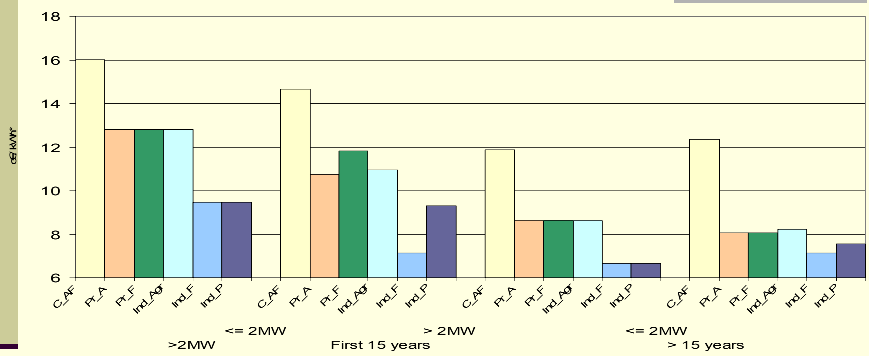
Forest harvesting and biomass
Catalonian Forest Technology Center

Biomass electricity taxes (RD 661/2007)



Public incentives (c€/kWh) for electricity production with biomass

** **C_AF**: energetic cultures (agriccultural and forest). **Pr_A**: agricultural residues. **Pr_F**: forest “residuals” and complementary thinnings. **Ind_Agr**: biomass from agricultural industries. **Ind_F**: from forest industries. **Ind_P**: black liquors paper industries.

Biomass electricity taxes: facts

- Main taxes are for energetic cultures
- Forest biomass is only better retributed than agricultural residues and industrial byproducts for > 2MW and 15 firs years.
- Slightly higher retribution for < 2MW plants than bigger. Esception for energetic cultures.
- As a consequence of this taxes and the lack of demand in Catalonia, some forest biomass has been already chipped and shipped to Italy, with higher biomass electricity taxes.

Perspectives

- Whole Spain:
  - RD 661/2007 has set up "game rules" of biomass electricity production, so different stakeholders are now evaluating and acting according this new legislation and all available raw materials.
  - Existing surplus of forest material available.
  - Competitive cost of forest biomass supply mainly for heating facilities.
  - Forest owners, and some technical and public adms are promoting the forest biomass developing process.
  - FERTILIZATION
  - LEARNING CURVE
- Specific for Catalonia:
  - Good base initiatives: forest owners tend to aggregate
  - Good results as example (i.e. Alp municipality, 5Eures IEE project).
  - Subsidies for forest biomass heating installations (up to 50% of budget)
  - Possible competence with the particle board industry? And with the main small wood sawmill?

Expert consultation

"EU Forest-based biomass for energy: cost/supply relations and constraints"

Summary and concluding remarks

Summary and conclusions

The present conclusion is the summary of the additional information provided by the experts of the consultation of "EU Forest-based biomass for energy: cost/supply relations and constraints" held in Joensuu, Finland on 18-19 September 2007. Some of the data provided require background information from the papers listed in the reference list.

Different studies use different assumptions concerning how the total and harvestable supply of forest residues can be calculated resulting in a cost-supply curve.

[METLA] assumed that 75 % would come from final fellings, 25 % from thinnings and 25 % of the 2005 forest growth increment could be used for energy: the rest would be partly used for satisfying the growth of existing wood industry and partly left. According to their assumptions, 200 million m3 /year felling residues can be collected economically at the present technical level.

In Finland 25 % of forest resources are already used in the energy sector. [EFI] Overall resource potential: there are certainly opportunities to improve management practices and in some countries, fertilisation can also result in significant increases of production with net greenhouse gas benefits.

The EFISCEN supply model gave ~ 40 % lower available residue quantity when considering environmental constraints compared to the baseline scenarios (instead of 29,2 Mtoe, 21 Mtoe only could be mobilised). However the results are very sensitive to the future carbon price value (ETS II).

A very basic question is: Should such a calculation be made for Europe or for distinguishable sub regions (E.g. The Baltic timbertrade region, Central Europe, East continental etc...) and then constructing the European c-s curve by adding the latter together? The discussion seemed to conclude that adding regional assessments would produce a more reliable output.

Expansion factors, energy content, water content;

In the different calculation methods there are differences between the t/m3 values, and the reason is the ***water content*** of the wood. Defining average water content is difficult, depending on the supply chain length and the method and time period of storage. In forestry materials in the Nordic countries after harvest, water content is around 50%, at the mill gate on average 40-45 %, and it is maybe lower in South EU (Italy – 40 %). The expected values in the energy sectors are far too optimistic. It is impossible to get cheap biomass with 30 % water content from forestry.

The ***calorific values*** and ***oven dry tonnes per solid m3*** are almost the same in every calculation method and varies from 300 to 700 kg/m3 depending on the species and fractions, so the specific conversion factor ranges vary significantly from 2,5 m3/t ≈ 300 kg/m3 to 2,1 m3/t or 600-800 kg/m3. The forestry statistics are in m3. They have to be converted to tonnes and energy for the calculations.

The need to standardise the units used to describe the supply, BDT (bone-dry tonnes = oven dry tonnes) was proposed as a standard unit - however it was noted that both dry and green mass, volumes and energy contents are relevant, and needed by different stakeholders. Nevertheless it is desirable to at least standardise the units for these different measures

Absolute technical constraints of residue recovery (e.g. % which can be picked up, extraction of needles);

The most important factors in the technical restrictions are the level of the mechanisation, infrastructure, topography, accessibility, accepted quality of the material by users and environmental constraints.

Regarding the expert estimate of the ***pick up rate*** after mechanical felling, the absolute technical constraint was put at 65 % and much less for manual felling (in fact it is not at all economic). The % economically recoverable varies from country to country. In the Czech Republic 80 % is the best technical practice, however this is only possible on < 15% slope, with mechanised felling. In areas with ***steep slopes***, where the ***mechanisation*** can be only low, i.e. in Spain the figure can be much lower.

In Italy the share of mechanised felling has risen from 2 to 10 %, and can reach 30 % maximum by 2020, like Austria now. More is almost impossible. In Sweden, typical recovery is 50 % but the best case in future, 75 % could be possible with whole tree harvesting, the 2020 figure can be higher. However collecting more wood residues could contribute significantly to preventing forest fires in Mediterranean ecosystems. In this case the high cost is justified by fire prevention.

The ***accepted quality of the material*** (e.g. some combustion technologies do not tolerate needles (i.e. biomass burners in Vienna)) is an important factor. Bioenergy plants need to look more at what quality fuel they can get for which price – and design a the plant to cope with the quality they can get for an economic price. In Sweden high quality chips are needed for small plants. The bigger one can digest everything. In Austria even bigger plants need high quality wood, they chip it themselves. More energy- and cost effective is to use the waste heat for drying.

For ***accessibility*** the technical constraints are the duration of the frozen period of the soil, transport tracking, long distance. On waterlogged soils in non frozen winter conditions it is impossible to collect as trucks sink into the road. Trucks with thicker tyres are being developed.

The indicators for ***environmental constraints*** are the same as for agriculture: biodiversity, site fertility, soil protection, water protection. The more intensive use of forest material calls for careful consideration on environmental effects. The available potential must be evaluated against the criteria of erosion, compaction and fertility. Specific attention must be paid to the effects of the removal of roots on the soil quality, possible impact of mechanical harvesting, peat use, nutrient losses.

Scandinavian soil is too low in minerals, so it would need compensatory fertilisation, which creates more expenses. Fertilisation costs are estimated at 500-1000 €/ha, in the case of Scandinavia, and the length of the optimal forest cycle may be changed for 15 years in some cases. Nobody wants to collect needles (which have high mineral content) but sometimes this cannot be avoided.

Stump harvesting is not legal in Italy. Recycling of ashes is used also in Italy and partly in Austria.

A question of great importance is what ***recovery rate*** can be assumed. This is *system specific* for residue harvesting, thus recovery is lower after manual felling than after mechanised felling, which will concentrate the residues more. Also it is *method specific*; some methods (e.g. adapted harvesting as in the Nordic) provides better concentration and more easy recovery than other. Thirdly it is *operator skill specific*; There is a notable difference in recovery rate depending on the skill of the operators involved.

It was also noted that for the expert estimate of 2/3 recovery (Finland) or 3/4 recovery (Sweden) after mechanised felling, no supporting data can be found. No recent investigation has been made of the recovery rate after final felling.

In the discussion of technical restrictions limiting the availability of the physical supply, it was noted that by 2020 technology will have been improved, thus technical restrictions are likely to decrease over time. New technologies, adaptation and higher degree of mechanisation will improve availability over the period. Still some forest areas are in topographical or pedological extremes (very soft ground, ground susceptible to soil compaction, very bouldery or steep terrain) and will probably not be accessible by mechanised methods.

Cost estimates

[METLA] cost estimates are derived from data from the following EU Member States: the Czech Republic, Finland, France, Hungary, Poland, Sweden, Spain and United Kingdom. In the ***cost of collection, forwarding, and transport*** the most variable cost factors in the countries are associated with ***labour costs***. This varies 5-27 €/man hour. The labour costs are much lower in the New Member States, but on the other hand the efficiency is much higher for example in the Scandinavian countries due to the more customary use of two shifts on machinery. This decreases the specific capital costs/output. The ***price of equipment*** (trailers, chipper, forwarder, harvester) is supposed to be the same. METLA also took into account the variability of the ***fuel costs*** in the different countries. However the differences were not as significant as in the labour costs.

For the **a*dministration costs in Finland*** 3,6 € /m3 was reported for logging residues and stumps, but for small trees around 5 € / m3. The JRC calculation assumes 3 € /m3.

[EFI] estimated a significant difference in modelled ***roadside costs*** of forest residues for the different species.

€/m3	Non-coniferous species	Coniferous species
Finland, Sweden	25	25
EU 15	35	53
NMS	25	35

METLA estimated the price ranges at which forestry resources can be supplied around 10-20 €/MWh or 18-40 €/m3. In Finland, Sweden and the Czech Republic it is lower, at 10-15 €/MWh due to the huge concentrated quantities available. In the Italian Alps the roadside price for fresh residues is 5-10 €/tonne. Costs are reduced by 15-20 % by whole tree harvesting.

The costs in Austria for the Guessing plant (8-10 MW) is 37,5 €/solid m3 (with chipping in road side or central). Price depends on water content: for 45 % moisture content (MC) it is 36 €/m3. They grow to 40 € delivered at the district heating plant at an average MC.

By comparison, the Finnish saw wood is now 70 €/m3 up from 50 last year; pulp wood is 35-40 €/m3 delivered down from a peak of 50-60 €/m3 last year.

In France, the delivered cost to 100 000 t/y plant of complimentary fellings is 45 €/tonne at 45 % MC (~ 82 €/dry tonne). Swedish typical roadside costs now are 20-22 €/m3 (50-55 €/dry tonne); in Finland maybe 2 €/m3 higher. The cost of Russian wood chips is about the same as Finnish pulp wood: 35-40 €/m3 (87-100 €/dry tonne).

According to the estimation of ***transport costs*** by trucks and train, the following values can be taken into account: For 20 km, about 1-2 €/m3 (truck) and 4-5 €/m3 (train)
For 100 km, about 6-7 €/m3 (truck) and 8-9 €/m3 (train).

The cost difference in EU15 was questioned by other experts who retained it as smaller. However this depends on how much the materials are already used by the pulp industry.

Even between spruce and pine they distinguished the cost figures of 20 €/m3 and 30 €/m3.

Forwarding and transport distance

The ***forwarding distance*** depends on the supply and the road network density. Variation in forwarding distance is the main cause of dispersion in delivered cost of wood chips within one country. No statistical data are available, just case studies; it was considered that the average forwarding distance is about 300 m, local variations are 200-500 m: in France around 500 m in average, in the Czech Republic 200-250 m, in Finland 270 m, so for the EU around 250 (200-300) m average forwarding distance can be estimated.

The ***transport distance*** to existing and larger plants as a function of supply and an infrastructure around varies in different countries. In Austria it is 45 km, on average, depending on the size of the plant, near Vienna (Vienna plant - 65 MW)) the maximum transport distance is 120 km because a good infrastructure is around.

There is a difference between the size of the trucks in the Nordic (60 t going to 80 t in Sweden and Finland) and other EU countries (40-50 t in rest of the EU).

In Italy 2 Mha from the 8 Mha of forest is served by infrastructure. There is no backhauls in Italy after trucking forest chips, however fuel-wood may be transported 300 km and here some backhauls are possible. Backhauls in Sweden and Finland are about 20 %.

Because of the learning effect, wood chips prices have gone down by 2 % per year in Sweden since the 1970s as production and productivity increased.

Size of plants

In Finland the need of energy defines the size of the plant (the range varies between Eno 0,8 MW to Pietasari 550 MW forest chips, residues and peat, Joensuu is 220/250 MW 50 % of wood 50 % peat). Nothing bigger is planned; the trend is towards decentralised 5-10 MW cogeneration plants (also in Spain).

There is a lot of competition (wood import from Russia) for supply to new generation plants (gasification plant 120 km from Joensuu which needs 50000 m3 /year at present (pilot) stage increasing to 1 million m3/year).

For Sweden the sizes are variable, mostly co-generation biomass plants. For heating and electricity production the optimal size is 70 MW. Decentralised co-generation plants with 5-10 MW are the trend also in Spain. In Austria there is a special ownership structure, with many small and only a few state-owned ones. Small scale owner structure generate small scale plant systems, big scale owners are going for big scale plants. For smaller units, problems were reported as well, being related more to the location than to the size of the unit.

Thinnings

The thinning depends on price and the technology size of the tree. In Italy if it is possible to get 60 €/fresh tonne, one can have a lot of thinnings. At 40 €/t thinnings are not interesting: Current price in Italy is 45 €/wet tonne (delivered and mechanized). The price for logging residues in Finland was 20-25 EUc/m3, 2-3 €/m3 for thinnings.

The real cost of small tree thinning is actually less, because the yield is increased at the end. In the Czech Republic on 14000 ha, there is no harvest and extraction of small trees.

Small plants reference fuel is gas or oil and they are not willing to pay for biomass. Fuel wood is more competitive if the carbon taxes are taken into account.

Taking away thinnings reduces the growth of the stand because it removes available nutrients.

Small forest holdings do not market for forest chips. Other impacts of using forest energy must be considered and they are supporting the energy use of wood from thinning.

Precommercial thinning already causes costs. The forest energy recovery can be seen as additional cost on this operation that is covered with silvicultural treatments that should be done anyway.

Small diameter trees

Small diameter trees and other materials from complementary fellings do not differ in composition from logging residues. Their markets, however, are often smaller and more local than those of logging residues. The typical customers are smaller units ranging from hundreds of kW to a couple of megawatts. As a result, the reference fuel is often oil or gas, which are at a very high price level, with today's gas/oil prices the offer to pay is 30 €/m3: just about enough for small trees. In Sweden small trees are expensive, but a large potential, ca 2,9 million ha below than 10 cm. Small trees react well to fertilisation: there is considerable scope for increasing yields in this way.

Fire hazard favours the extraction of all logging residues and whole tree harvest to prevent ignition. Also in this case, a large part of harvesting costs can be assigned to forest fire prevention.

Complementary fellings

Complementary fellings are the area, where competition for other uses (pulp, particle board) comes into the picture and it can have a substantial impact both on the availability and costs of forest biomass for energy.

The main question with complementary fellings is the other uses of small trees. With current prices, harvesting from complementary fellings is not very attractive for forest owners.

Sustainability is also an important issue in complementary fellings. The question is which part of the potential actually can come to the markets. Stems can be delimbed and thus the nutrient loss is minimised. At the same time part of the biomass is lost, but forwarding costs can be decreased. In addition, the users of high quality chips can usually pay a higher price for the feedstock.

The estimated overbark vs. underbark proportion is around 11 %/13 % for coniferous/deciduous. The constraint is the nutrient availability.

The current ***road side prices for complementary fellings*** are 16 € – spruce and 26 € – prime.

In France there is a high price for chips from complementary felling: for a plant using 100 000 tonnes/year delivered cost is 200 € /MW, 45 €/fresh ton. Between the French regions there is a great variability of costs.

Wood chips from complimentary fellings in France

€/MWh	€/dry tonne	Plant size kt/yr
15	35	200
21	47,5	3200

Price of raw material has been increasing, but costs of supply have gone down simultaneously.

Unrecorded fellings

Fuelwood extraction is not always ***recorded officially***. On the other hand the increment figures are outdated and thus underestimating the current growth. In several countries the use of firewood is many times larger than statistical figures. However, firewood is coming from hardwood stands having a significantly higher market price than that of wood chips. In France over 24 million m3 is harvested and registered as firewood, in Italy 18 million m3 is used compared to an official figure of 2,8 M m3. Total biomass increment is 144 million m3/year. Also in Spain a large part of firewood recovery is not registered.

IIASA-Laxenburg has compiled the best data on wood use and availability, and has some discussion on unregistered fellings. The share of ***"unrecorded" fellings*** is estimated to be lower in Scandinavia than the rest of Europe. In Italy unregistered felling is difficult to estimate even on land which is registered in the forest inventory.

Direct fellings for firewood are recorded in national inventories in Sweden and Finland so they have estimated data for unregistered fellings. Thus harvests for firewood are in the NFI-statistics. Such systems do not exist in countries like Germany. Part of the wood may come from agricultural lands that are outside the forest inventory.

Import

Establishing ***import cost curves*** is a difficult task because of the complex trade issues (taxes, and also trade of biomass & biofuels) and the inter-relationship with competition between energy and traditional forest products and their connection to world markets. Factors influencing the forest market have to be taken into account. However, as an indication, one could expect imports to rise to maybe 10 % of EU supply if the cost of wood chips rose to 90 €/tonne.

Russia was responsible for 1/3 of imported round wood and industrial chips (5 millio m3 chips for paper, but not for energy). There was no alternative use in Russia and that is why it is imported to Finland, where the sawmill capacities are available. In the last two years there was a price increase in forest products because of harvesting problems and Russian export taxes. This is set at 50 € /m3 roundwood. The idea is to keep it at home to create added value in Russia. This probably will affect also the chip prices. The spruce prices went up from 50 to 70 € /m3 in the last years.

However in 2007 there were high prices in Finland and Russia because of the bad weather conditions. The forest owners still behave in a traditional way; they use their stands as a bank and cut when they need money. Now the new tax regime allows spreading income over 10 years, so they should behave more according to economic theory.

For the forest trade model harmonisation of data (different countries different definitions etc..) is needed, however it is difficult to get the trade data because they are not publicly accessible.

Other constraints

Fragmented ownership can complicate the forest resource mobilisation. This is a problem in many European countries (e.g. New Member States, Germany). In France, 10 % of the forest privately owned is <1 ha, 25 % <4 ha. In the New Member States and in Italy there are sometimes difficulties to establish the correct ownership. Some system of compulsory or default cutting is needed.

In order to increase ***bioenergy acceptability*** by the citizens in Italy it was very important that the biomass-based energy be distinguished from the incinerators. Therefore the use of treated wood has been considered as unacceptable. The situation is different in Germany where public acceptability is easier to maintain, due to the fact that citizens acknowledge the near zero harmful emissions.

Learning curves

Learning curves have been shown to produce reasonable results in forest bioenergy applications and this gives hope for increased productivity of the bioenergy sector. Under the demand driven situation as we have, this could allow for quite significant improvements in a relatively short time perspective, already by 2020.

Björheden estimates a learning rate of 12-15 % cost reduction for each doubling of cumulative production, applying 20 % (or even 30%) impact of market doubling in 20 years in forest in learning curves, because technology transfer is already there.

For the overall resource potential: there are certainly opportunities to improve management practices and in some countries, fertilisation can also result in significant increases of production with net greenhouse gas benefits.

The learning curves are applicable for different countries, the conditions are similar in Finland Sweden and Central Europe, but unit costs are much higher. The reason could be that the harvesting is different, the operators are not experienced (in some cases /Latvia/ the very skilled good operators are present, but there is no understanding behind the whole supply chain: in Italy and Germany there is the technology and machines but they are not used, there is a lack of knowledge on use, and the entrepreneurs are missing to do it)

Faster learning curves could be experienced in some cases if the countries and products (thinning, logging, industrial wood, etc.) are differentiated.

Certification

Certification of biofuels was also discussed as an important factor that can influence both costs and availability. European countries are world leaders, considering the share of forest area certified. However, the existing forest certification schemes are not specific enough regarding the criteria for sustainable biomass removals. Work is under way in different countries and internationally to improve the certification standard in this direction. Imports from Russia are not all certified environmentally. The forest management in Italy, France and Spain are quite well certified, which according to the experts' statements, satisfies the requirements for liquid biofuel as well.

Overall conclusions

- European cost-supply curves are best built up from regional curves. One could start with broad regions and then refine with data from national experts.
- JRC's approach, built on METLA data is a good starting point. EFI has a completely different market-based approach which models price rather than cost.
- Adequate cost-supply model for imported wood are presently unavailable.
- The most useful measure of wood chips is oven-dry tonnes; however most input data is for solid m3.
- Learning curves are important and fit Swedish data well.

- The recovering of residuals will improve with technology and more mechanized cutting, but some terrain will remain impossible.
- Complementary fellings have more scattered availability then forest residuals, and therefore more suitable for local CHP and heating plants. Prices need to rise for this use to expand.
- If a bioenergy plant needs large volumes of cheap chips to be viable, it must be built to accept fresh, wet material.
- Unregistered fellings mostly for firewood and out-dated forest stand data are large sources of uncertainty in evaluating extra forest resources in some EU countries. EFSOS/UNECE studies are looking into this.
- Fertilisation can increase yields of smaller trees in some countries.
- Wood certification does not cover forest residuals at present.

Expert consultation

"EU Forest-based biomass for energy: cost/supply relations and constraints"

List of participants

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Expert Consultation "EU Forest-based biomass for energy: cost/supply relations and constraints"

Joensuu, Finland

from 18 Sept 2007 to 19 Sept 2007

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Expert consultation
"EU Forest-based biomass for energy: cost/supply relations and constraints"

Websites of participating organisations

Institute of Environment and Sustainability (IES, JRC, EC)
http://re.jrc.ec.europa.eu/biof/
http://www.jrc.cec.eu.int/Units/re

European Forest Institute (EFI)
http://www.efi.fi

Lulea University of Technology, Sweden
http://www.ltu.se/inst/ies

International Institute for Applied Systems Analysis, Austria (IIASA)
http://www.iiasa.ac.at

Forest Management Institute, Czech Republic (UHUL)
http://www.uhul.cz

Finnish Forest Research Institute, Finland (METLA)
www.metla.fi

Forestry Research Institute of Sweden
http://www.skogforsk.se/

Forest Technology Centre of Catalonia, Spain
www.ctfc.cat

AFOCEL-FCBA, France
www.afocel.fr
www.fcba.fr

Trees and Timber Institute, Italy (IVALSA-CNR)
http://www.ivalsa.cnr.it

Expert consultation

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Background document

COST-AVAILABILITY CURVES FOR EU25 FOREST CHIPS 2020

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METHODOLOGY

Introduction

The curves sum two sources of forest chips/forest residues and additional roundwood felling. They do not include traditional firewood, crop residues, short rotation forestry/coppice (farmed wood), nor wood wastes, produced at wood-processing plants (bark, sawdust) - which are already used. To find the EXTRA potential for wood-for-energy, one should also subtract from the availabilities the amount of forest residues already used. The use figures are not available for all of the EU. As an indication, in 2004 Sweden used 0.36 Mm3 forest residues [Lundmark].

1. FOREST RESIDUES

(branches, tops, sometimes roots; now usually left in the forest after felling)

The maxima of the curves correspond to the limits estimated by METLA for what is available, limited by what can technically be removed, taking into account how much can be picked up practically.

The costs comprise:

1. Collection and chipping cost
2. Owners' compensation
3. Cost of returning ash to forest
4. Forwarding cost to roadside
5 Road transport cost
6 Administration

For estimating costs, EU25 was divided into 3 zones: Sweden-and-Finland, rest of EU15, and the New Member States.

METLA gives costs for Finland, France and Poland, as a function of plant size. These are NOT national cost-supply curves. The only credible national cost-supply curve which could be found is from Lundmark, for Sweden, but this is only for roadside cost (sum of costs 1 to 4). A wide range of roadside costs are indicated caused by different forwarding distances due to the variation in road network density within Sweden. The variation in supply is roughly linear with this variation in cost up to his maximum availability of residues.

1.1 Roadside cost of residuals

The lowest point on the METLA curve for Finland should be the roadside cost, and it agrees with the lowest roadside cost for Sweden given by Lundmark. (The IIASA report includes also cost items 2 and 3, but his lowest cost is for the minimum forwarding distance, whereas METLA assume a fixed nominal forwarding distance). Furthermore, there is a similar correspondence for the lowest point on the METLA curve for France and another curve we obtained from French industry sources giving cost vs. plant size. So we used the lowest METLA points for the lowest point on the cost-supply curves, using prices for Finland/Sweden, France and Poland as proxies for our 3 EU25 regions.

For Sweden and Finland, the roadside cost-supply curve of Lundmark (for Sweden) was adopted but scaled the availabilities so that the maximum availability corresponded to that given by METLA, which takes into account the fraction of residues which can actually be picked up (taking this fraction into account, METLA and Lundmark's availabilities for Sweden agree). Then the availabilities have been increased by 27% to account for the increase in fellings foreseen between 2003 and 2020, according to METLA, quoting the ETTS-V study.

For roadside costs in NMSs the minimum METLA cost for Poland was used and added Lundmark's forwarding-cost-dispersion for Sweden. Again a 27% availability increase has been applied for 2020.

For the roadside costs in the rest-of-EU15, I used the minimum cost for France from METLA, and added half Lundmark's forwarding-cost-dispersion, on the basis that road density in this area is never as low as in remote parts of Sweden. Again I applied a 27% availability increase for 2020.

Finally, for all EU25 1 Euro per solid m3 has been added as administration costs (being 1/3 of the administration costs for delivered pulp wood quoted in Lundmark: the other 2/3 were attributed to transport administration: see below).

1.2 Delivered Cost of residuals

To get from roadside cost to delivered cost we have to add the road transport costs for the chips. After Lundmark, road transport costs would not correlate with forwarding costs. Furthermore, road transport shows less range than forwarding costs, so it is acceptable to simply add to the dispersion of roadside costs, a single road transport cost for each given plant size and zone of the EU.

METLA calculated road transport costs on the basis of the national average resource density and a circular collection area around each plant. This is a reasonable assumption for Finland, because the fraction of Finland covered by commercial forest could roughly compensate the fact that collection areas are never circular. However, a much smaller fraction of France is covered by commercial forest, so this procedure overestimates road transport costs in France. To compensate, the availability of residues has been doubled to a plant for a given METLA road-transport-cost for France and rest-of-EU15. On the same basis I multiplied the residues available for a given METLA transport cost in NMS by 1.5. These factors result in believable comparative transport costs between the three zones of EU.

Next the annual wood consumption has been calculated for a 10 MW (thermal) and 100 MW (thermal) plant in the JEC WTW spreadsheet. Then these annual supply figures were found on the modified METLA curves, the cost-of-road-transport for these two sizes of plant in the three EU 25 areas. After the dispersion of roadside costs (in the "main" spreadsheet) and finally 2euros/solid m3 of transport-administration costs has been added; (Lundmark quotes 3 euros/m3 for administration of pulp wood transport, but in this model 1 euro/m3 has been already for attributed administration costs for of getting it to roadside). The same figures have been used for administration costs for pulp wood and residues even though the residues are more expensive to transport (lower packing density), because the residues-transport operation is likely to be repeated year-on-year in a regular contract.

2. ADDITIONAL ROUNDWOOD FELLING

2.1 Maximum availability

The growth increment in EU commercial forests is greater than the annual rate of felling. Taking into account the expected increase in consumption by the wood industry, METLA estimate that a further 25% of the EU roundwood balance could potentially be cut for energy purposes (the figure is only 25% because it takes into account the expected increase in fellings for the wood/pulp industry). I summed this quantity for our three zones of EU25 to give the maximum availability of roundwood. These figures include the technically available residues of the roundwood. I did not consider collection of thinnings, which after Lundmark is the most expensive form of wood (this could be added on at the high-cost end of the curve).

2.2 Roadside Cost

METLA figure 12 gives average roadside prices of pulpwood in some EU countries in 2002: they vary according to species and location. For Sweden and Finland the average price of the cheaper species is about 23.5 euros/m3. To this the cost of chipping has to be added: 3 euros/m3 according to Lundmark. He (fig. 8) reports a variation around the average price of +/- 2.5 euros/m3 because of the variation in forwarding distance. Thus for Sweden and Finland my roadside woodchip price varies from 24 to 29 euros/solid m3. In accordance with Lundmark's fig.8, the cost-supply curve is linear.

Although forwarding distances may vary less in the rest-of-EU15, METLA shows a significant variation between roadside prices in Germany and Austria. This is reflected by a larger range in roadside roundwood chip prices: 24 to 32 euros/solid m3.

For New Member States, METLA only gives roundwood prices for Lithuania and Estonia: both much lower than in the rest of EU; but this differential is unlikely to stay so large as the market develops and wages increase in NMSs. The cost range was fixed at 18-23 euros/solid m3 to be consistent with my cost range for residues in the NMSs.

2.3 Delivered Cost

Although the cost of chipping has been added to the roadside-cost (in accordance with IIASA report), it would generally be cheaper to deliver whole trees to the processing plant and chip them there. Accordingly, I estimated transport costs for the additional roundwood to be 70% of the corresponding ones for chipped forest residues, explained above.

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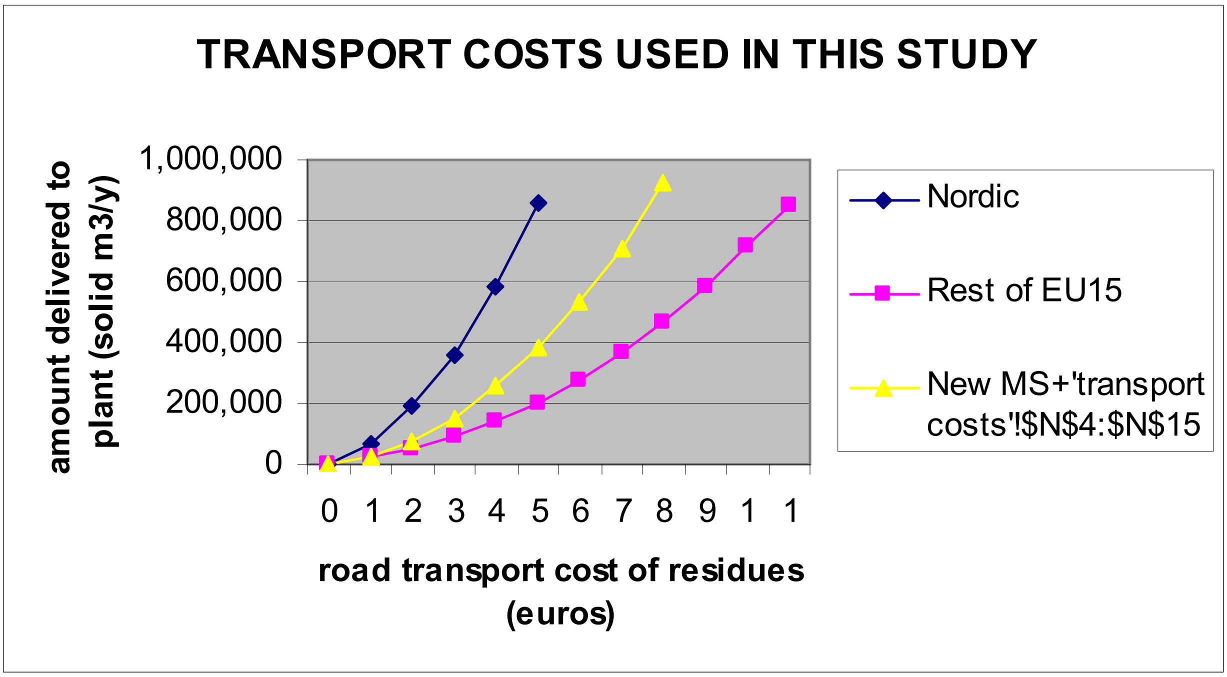
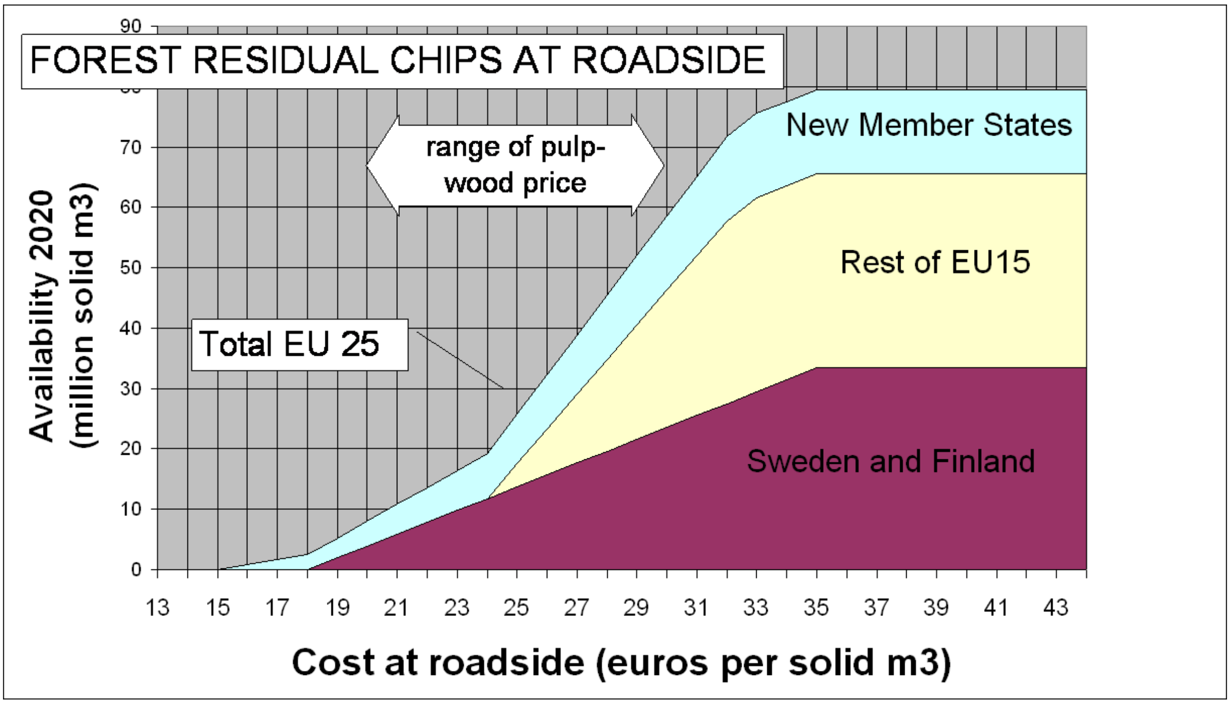
Lundmark R.: The supply of forest-based biomass for the energy sector: the case of Sweden. International Institute for Applied Systems Analysis, (IIASA) Interim report IR-03-059, www.iiasa.ac.at

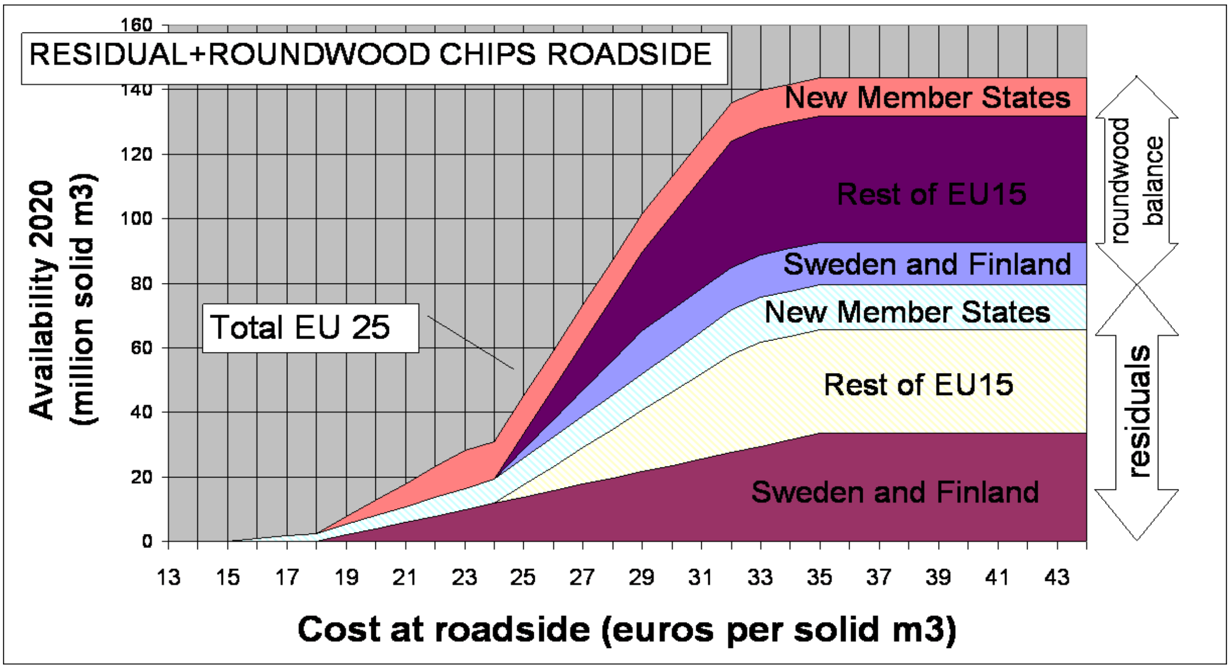
EU25 roundwood

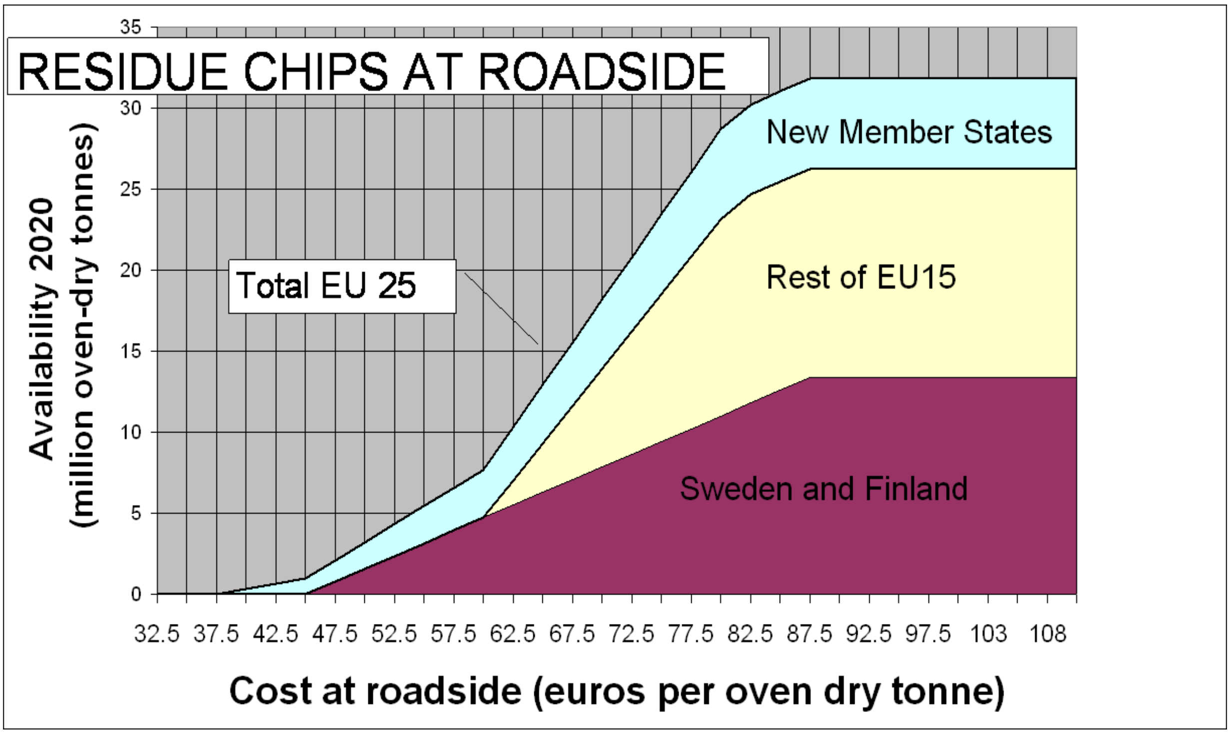
	2003	368	Mm3
estimated 2020 (METLA, ETTS-V)		466	Mm3
MULTIPLYING FACTOR FOR 2003 to 2020		**1.27**	

METLA Countries	**Total felling residues 2003** Total felling residues (mil m3/year)	Available felling residues	**2020 PROJECTION** Total felling residues (mil solid m3/year)	Available felling residues	AVAILABLE BALANCE 2003
France	22.6	8.6	28.6	10.9	10.2
Austria	10.1	2.9	12.8	3.7	2.7
Belgium	2.6	1.1	3.3	1.4	0.3
Denmark	1.2	0.4	1.5	0.5	0.4
Germany	23.4	6	29.6	7.6	13.9
Greece			0.0	0.0	0
Ireland	1.3	0.6	1.6	0.8	0.4
Italy	2.9	0.7	3.7	0.9	3.1
Luxembourg		0.2	0.0	0.3	0
Netherlands	0.6	0.2	0.8	0.3	0.3
Portugal	3.6	1.3	4.6	1.6	0.5
Spain	4.4	1.6	5.6	2.0	5.7
United Kingdom	4.4	1.8	5.6	2.3	1.7
Total EU 15	**77.1**	**25.4**	97.6	32.2	**39.2**
			0.0	0.0	
Sweden	35.2	15	44.6	19.0	6.9
Finland	26.7	11.4	33.8	14.4	6.3
Total nord	**61.9**	**26.4**	78.4	33.4	**13.2**
			0.0	0.0	
Cyprus			0.0	0.0	0
Czech Rep.	8.9	3.2	11.3	4.1	1.5
Estonia	1.6	0.6	2.0	0.8	0.6
Hungary	2	0.7	2.5	0.9	1.2
Latvia	2.9	1	3.7	1.3	1.5
Lithuania	2.2	0.7	2.8	0.9	1.1
Malta			0.0	0.0	0
Slovakia	3	0.9	3.8	1.1	1.7
Slovenia	1.1	0.3	1.4	0.4	1.3
Poland	12.5	3.6	15.8	4.6	2.9
Total New	**34.2**	**11**	43.3	13.9	**11.8**
Total EU25	**173.2**	**62.8**	219.3	79.5	**64.2**

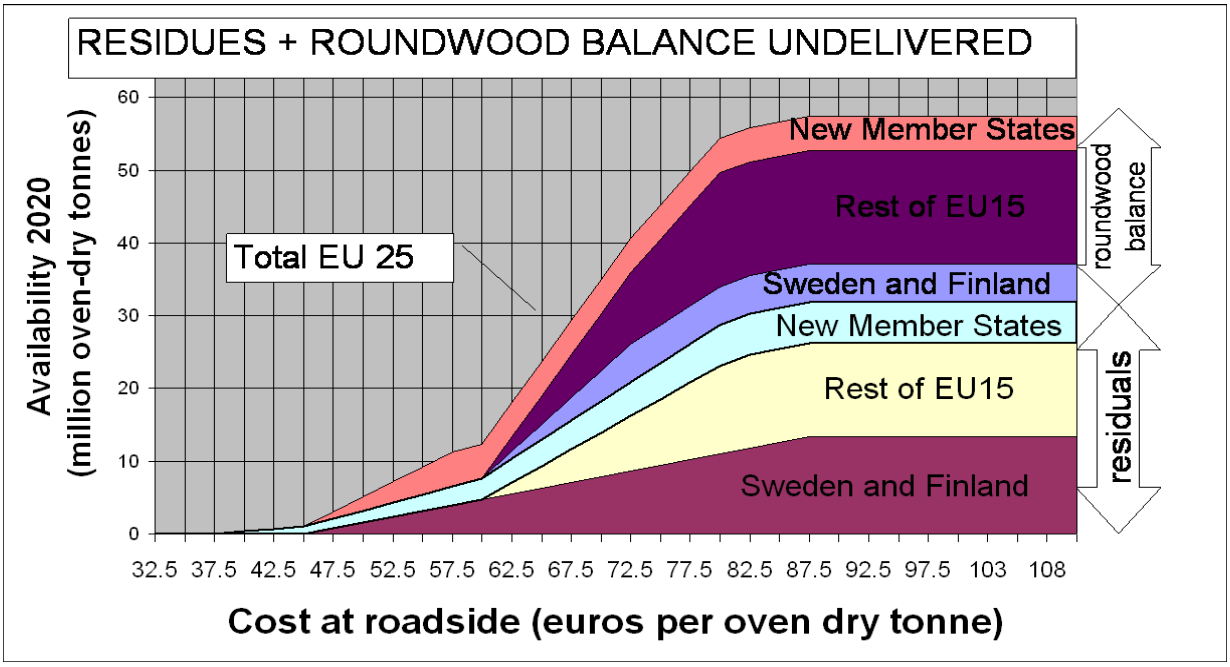

TRANSPORT COSTS USED IN THIS STUDY
amount delivered to plant (solid m3/y)
1,000,000
800,000
600,000
400,000
200,000
0
0 1 2 3 4 5 6 7 8 9 1 1
road transport cost of residues (euros)
Nordic
Rest of EU15
New MS+'transport costs'!$N$4:$N$15


FOREST RESIDUAL CHIPS AT ROADSIDE
range of pulp-wood price
New Member States
Rest of EU15
Total EU 25
Sweden and Finland
Availability 2020 (million solid m3)
Cost at roadside (euros per solid m3)

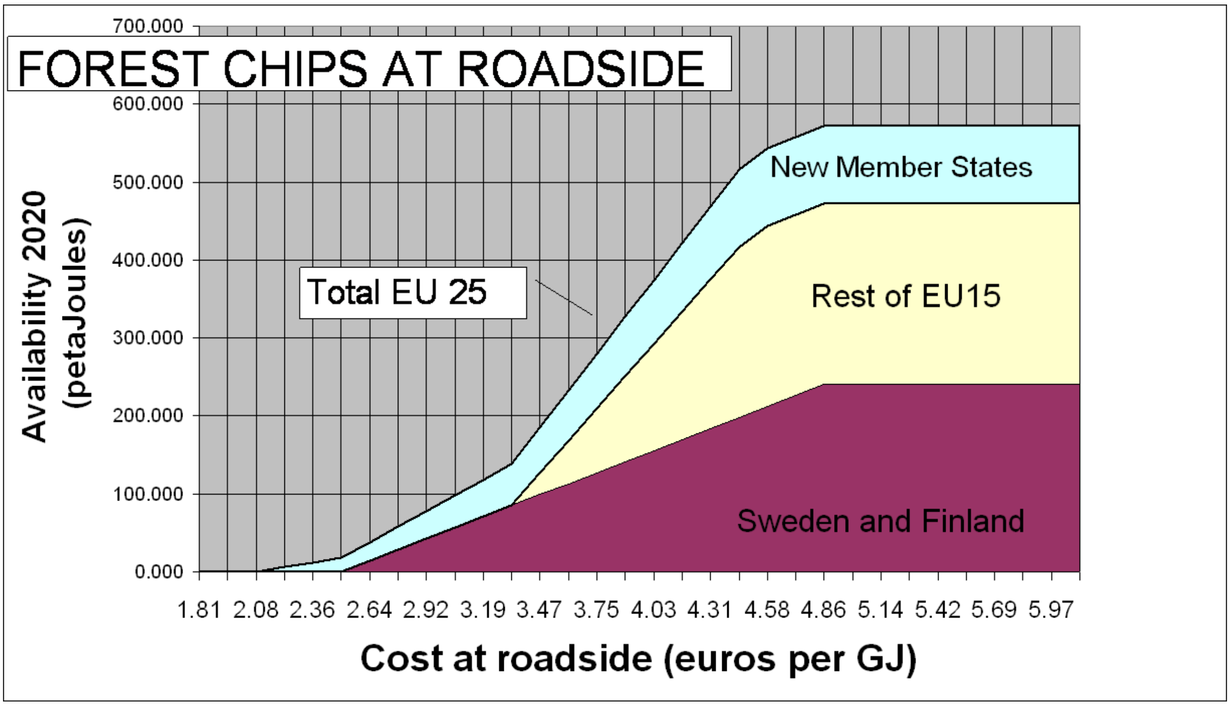

RESIDUAL+ROUNDWOOD CHIPS ROADSIDE
New Member States
Rest of EU15
Sweden and Finland
New Member States
Rest of EU15
Total EU 25
Sweden and Finland
roundwood balance
residuals
Availability 2020 (million solid m3)
Cost at roadside (euros per solid m3)



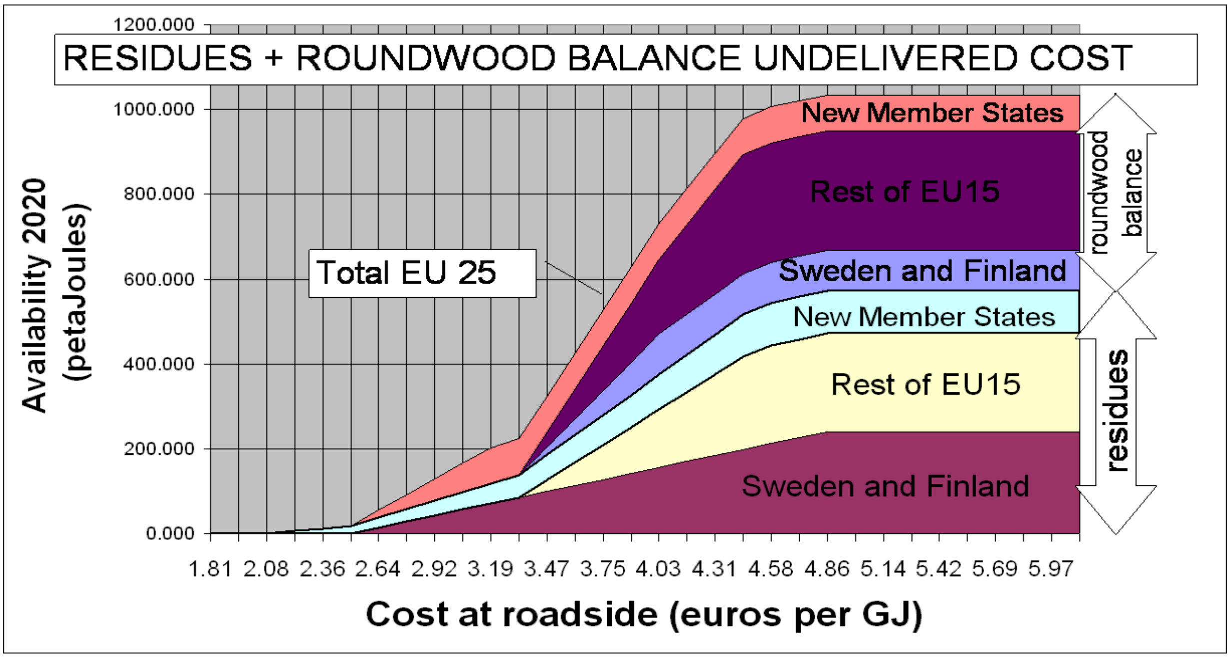
RESIDUE CHIPS AT ROADSIDE
Availability 2020 (million oven-dry tonnes)
0
5
10
15
20
25
30
35
Total EU 25
New Member States
Rest of EU15
Sweden and Finland
32.5 37.5 42.5 47.5 52.5 57.5 62.5 67.5 72.5 77.5 82.5 87.5 92.5 97.5 103 108
Cost at roadside (euros per oven dry tonne)



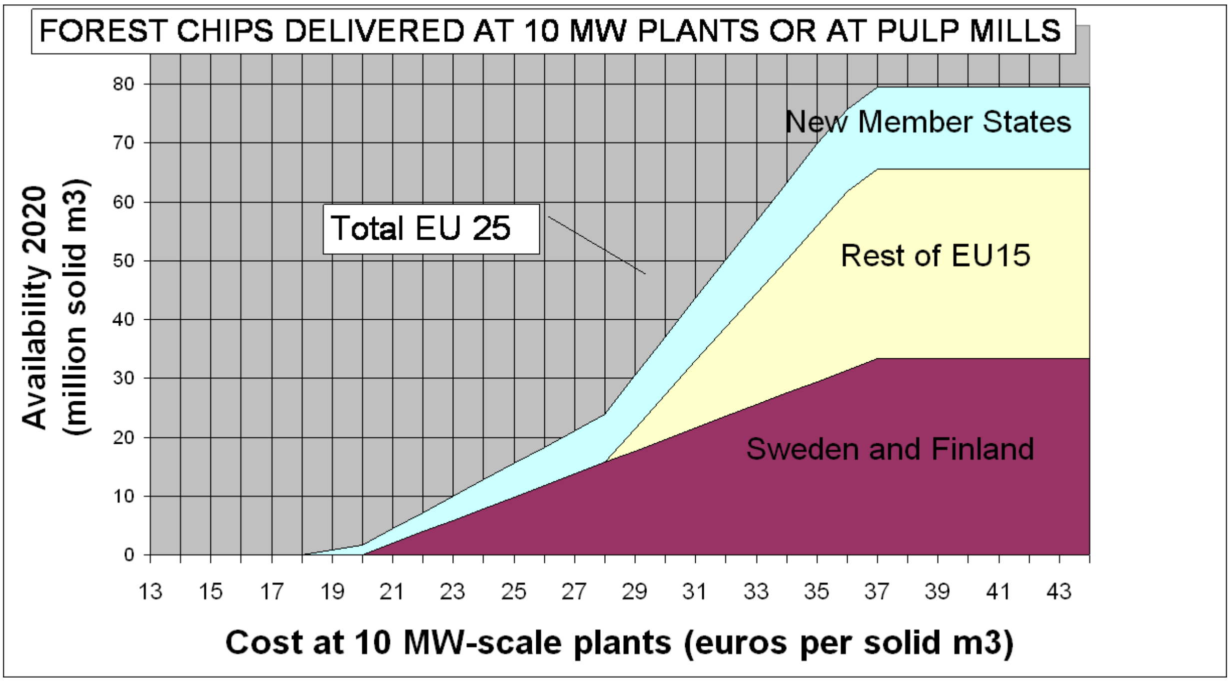
RESIDUES + ROUNDWOOD BALANCE UNDELIVERED
Availability 2020 (million oven-dry tonnes)
0
10
20
30
40
50
60
Total EU 25
New Member States
Rest of EU15
Sweden and Finland
New Member States
Rest of EU15
Sweden and Finland
roundwood balance
residuals
32.5 37.5 42.5 47.5 52.5 57.5 62.5 67.5 72.5 77.5 82.5 87.5 92.5 97.5 103 108
Cost at roadside (euros per oven dry tonne)

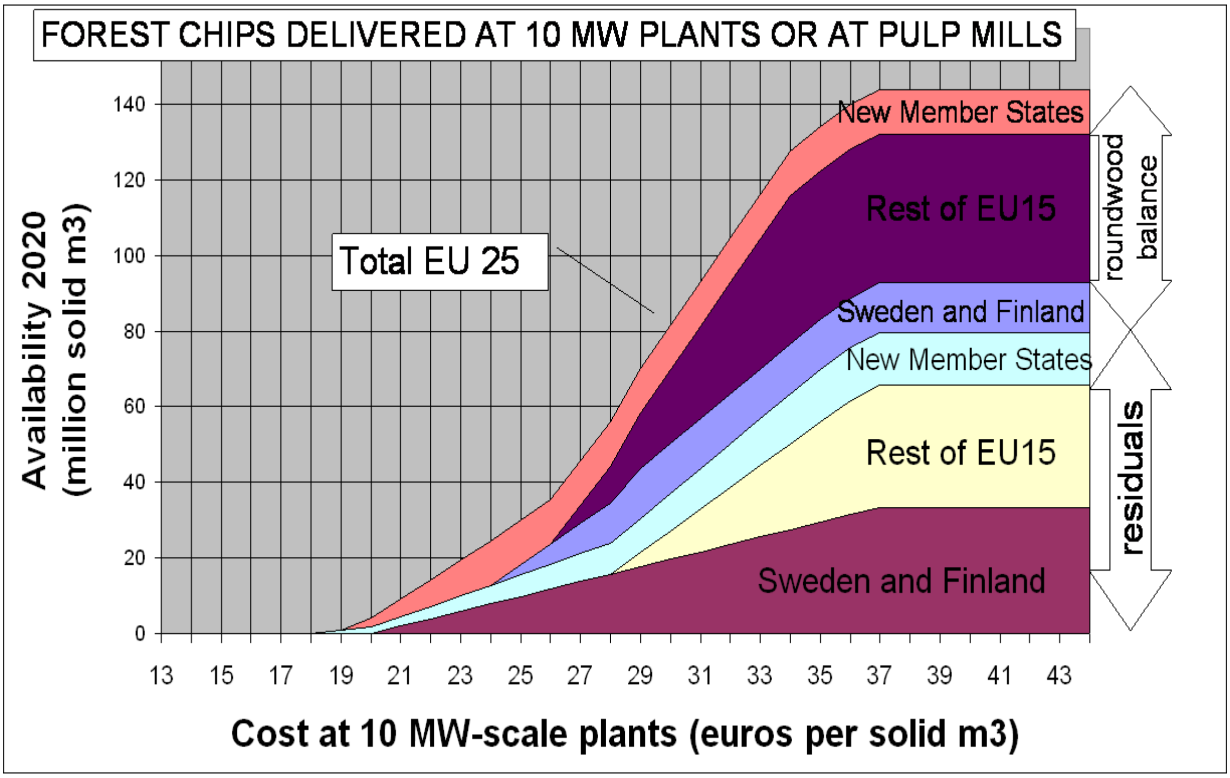


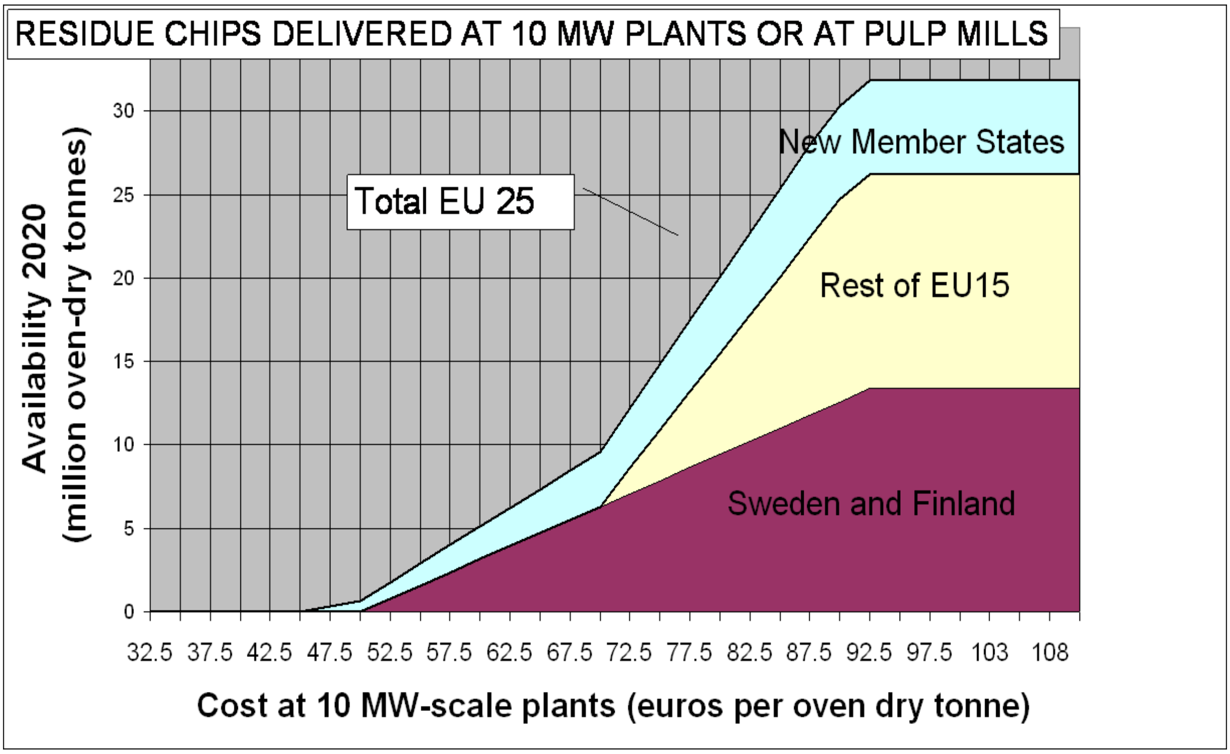
FOREST CHIPS AT ROADSIDE
Availability 2020 (petaJoules)
700.000
600.000
500.000
400.000
300.000
200.000
100.000
0.000
Total EU 25
New Member States
Rest of EU15
Sweden and Finland
1.81 2.08 2.36 2.64 2.92 3.19 3.47 3.75 4.03 4.31 4.58 4.86 5.14 5.42 5.69 5.97
Cost at roadside (euros per GJ)

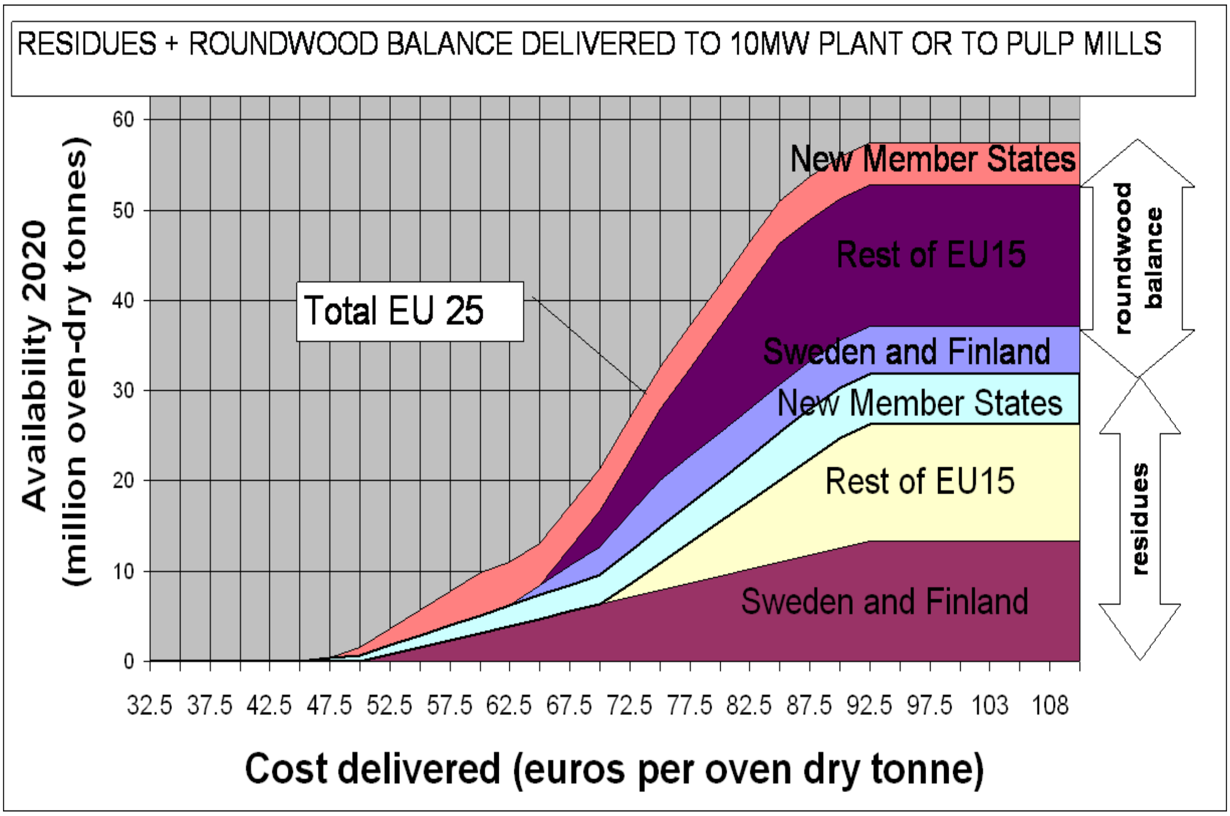


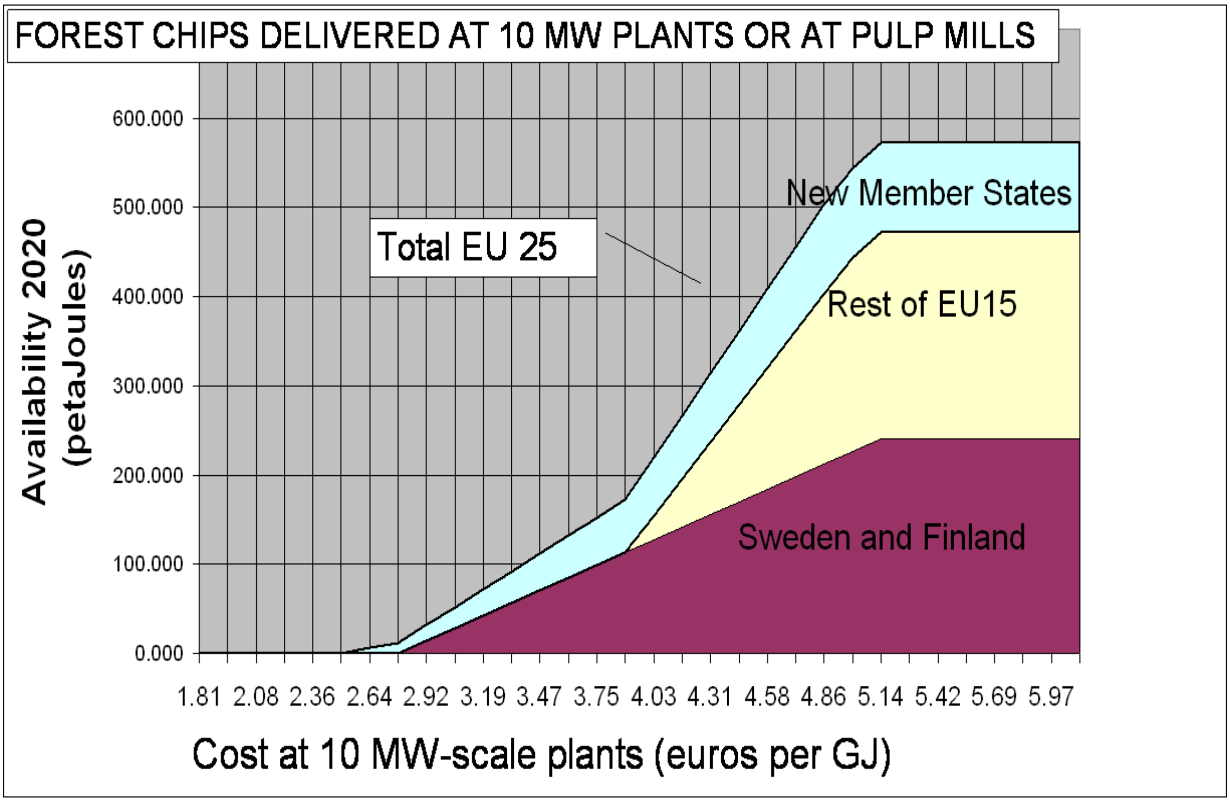
RESIDUES + ROUNDWOOD BALANCE UNDELIVERED COST
Availability 2020 (petaJoules)
1200.000
1000.000
800.000
600.000
400.000
200.000
0.000
Total EU 25
New Member States
Rest of EU15
Sweden and Finland
New Member States
Rest of EU15
Sweden and Finland
roundwood balance
residues
1.81 2.08 2.36 2.64 2.92 3.19 3.47 3.75 4.03 4.31 4.58 4.86 5.14 5.42 5.69 5.97
Cost at roadside (euros per GJ)

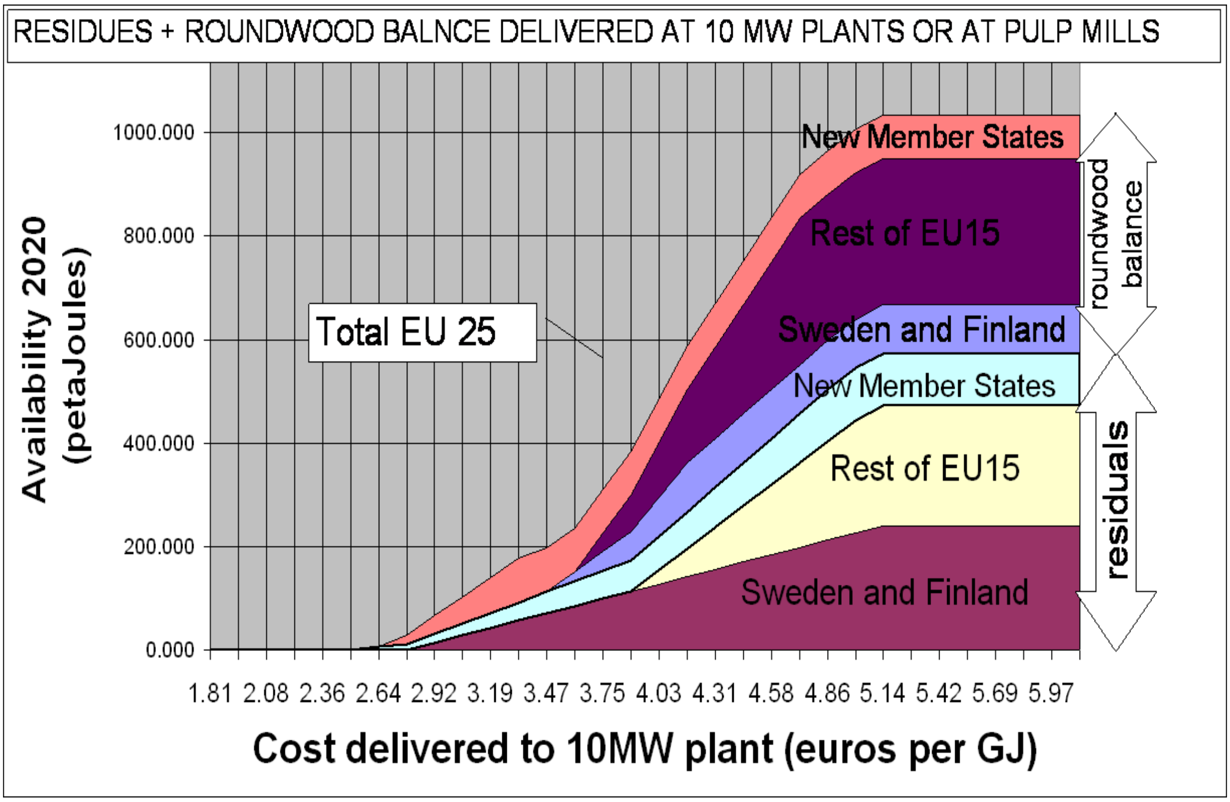

FOREST CHIPS DELIVERED AT 10 MW PLANTS OR AT PULP MILLS
Availability 2020 (million solid m3)
0
10
20
30
40
50
60
70
80
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
43
Cost at 10 MW-scale plants (euros per solid m3)
Total EU 25
New Member States
Rest of EU15
Sweden and Finland

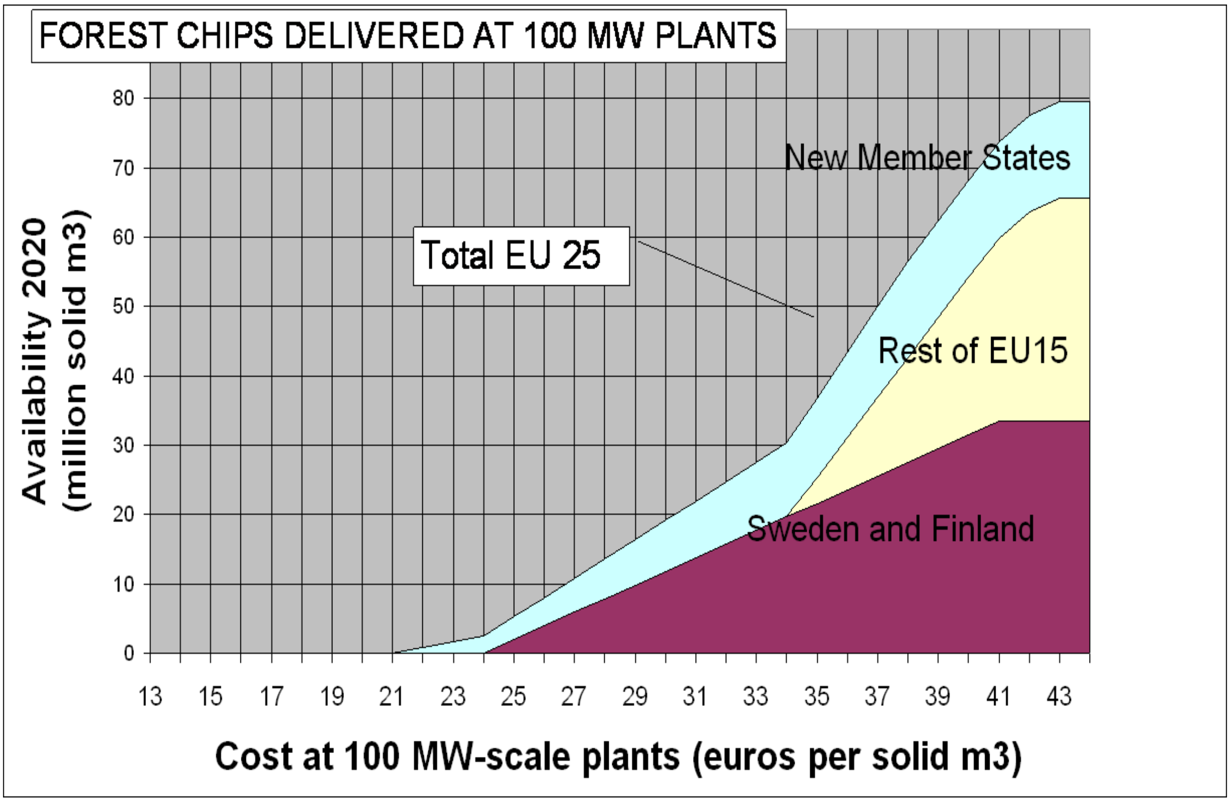

FOREST CHIPS DELIVERED AT 10 MW PLANTS OR AT PULP MILLS
Availability 2020 (million solid m3)
0
20
40
60
80
100
120
140
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
43
Cost at 10 MW-scale plants (euros per solid m3)
Total EU 25
New Member States
Rest of EU15
Sweden and Finland
New Member States
Rest of EU15
Sweden and Finland
roundwood balance
residuals

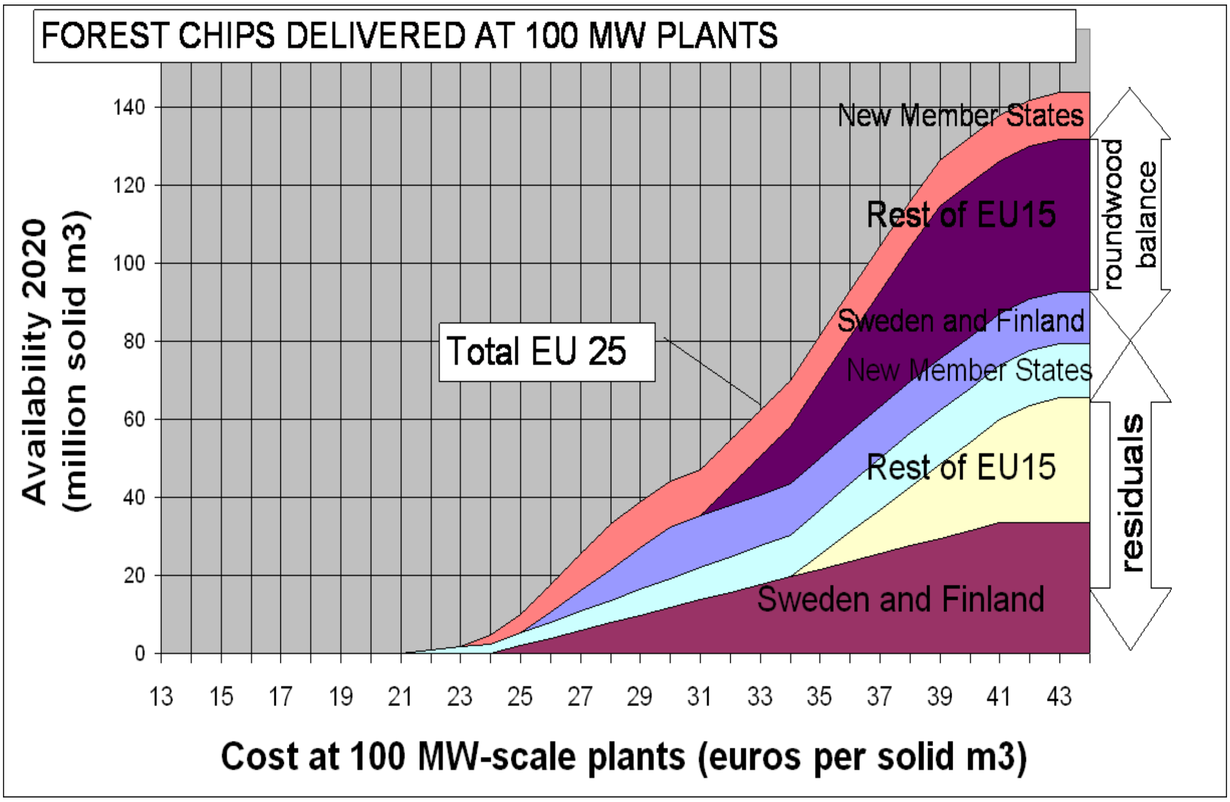

RESIDUE CHIPS DELIVERED AT 10 MW PLANTS OR AT PULP MILLS
Availability 2020
(million oven-dry tonnes)
30
25
20
15
10
5
0
Total EU 25
New Member States
Rest of EU15
Sweden and Finland
32.5 37.5 42.5 47.5 52.5 57.5 62.5 67.5 72.5 77.5 82.5 87.5 92.5 97.5 103 108
Cost at 10 MW-scale plants (euros per oven dry tonne)

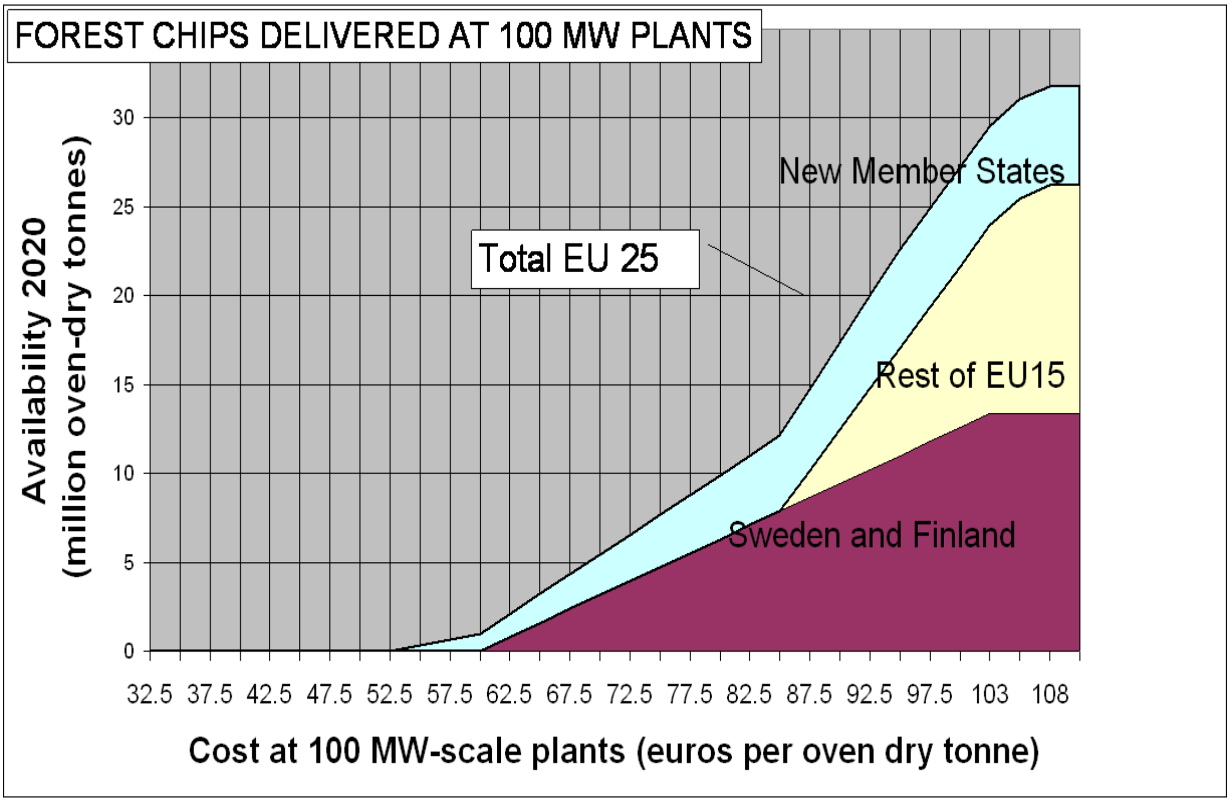

RESIDUES + ROUNDWOOD BALANCE DELIVERED TO 10MW PLANT OR TO PULP MILLS
Availability 2020
(million oven-dry tonnes)
60
50
40
30
20
10
0
Total EU 25
New Member States
Rest of EU15
Sweden and Finland
New Member States
Rest of EU15
Sweden and Finland
roundwood balance
residues
32.5 37.5 42.5 47.5 52.5 57.5 62.5 67.5 72.5 77.5 82.5 87.5 92.5 97.5 103 108
Cost delivered (euros per oven dry tonne)

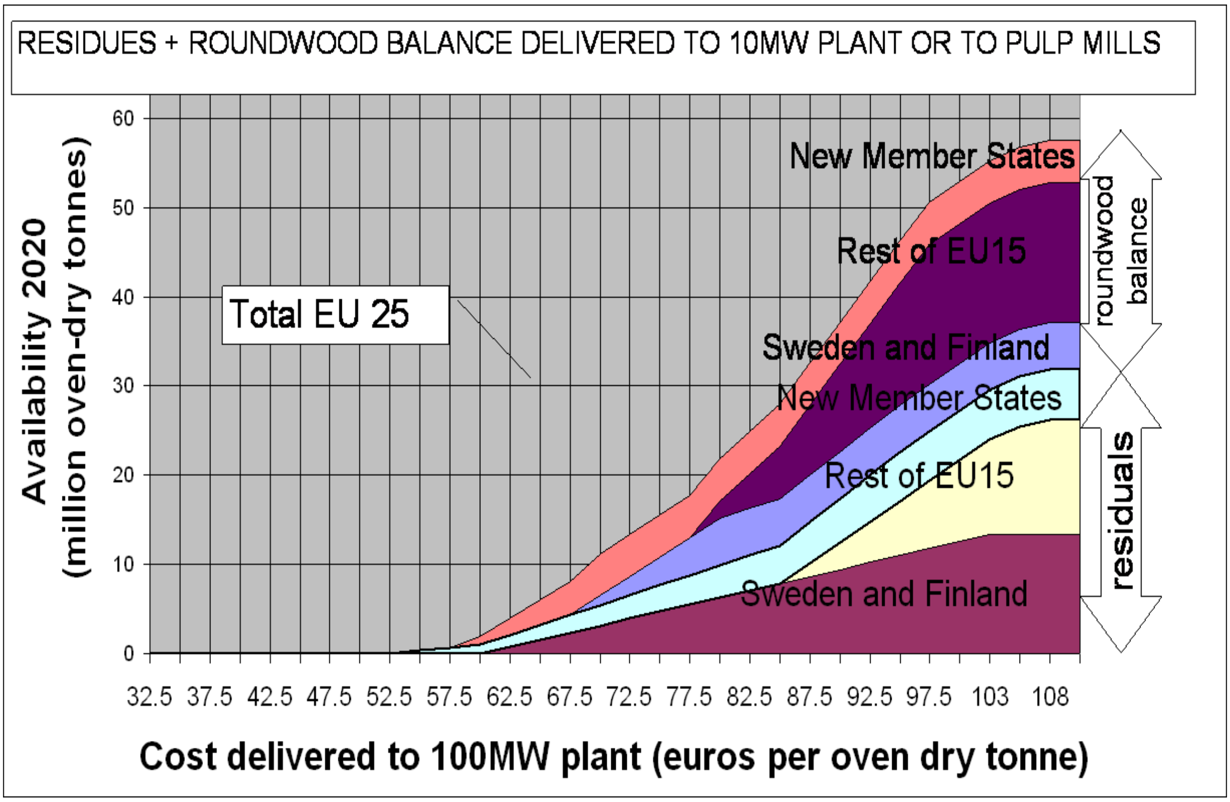

FOREST CHIPS DELIVERED AT 10 MW PLANTS OR AT PULP MILLS
Availability 2020 (petaJoules)
600.000
500.000
400.000
300.000
200.000
100.000
0.000
Total EU 25
New Member States
Rest of EU15
Sweden and Finland
1.81 2.08 2.36 2.64 2.92 3.19 3.47 3.75 4.03 4.31 4.58 4.86 5.14 5.42 5.69 5.97
Cost at 10 MW-scale plants (euros per GJ)

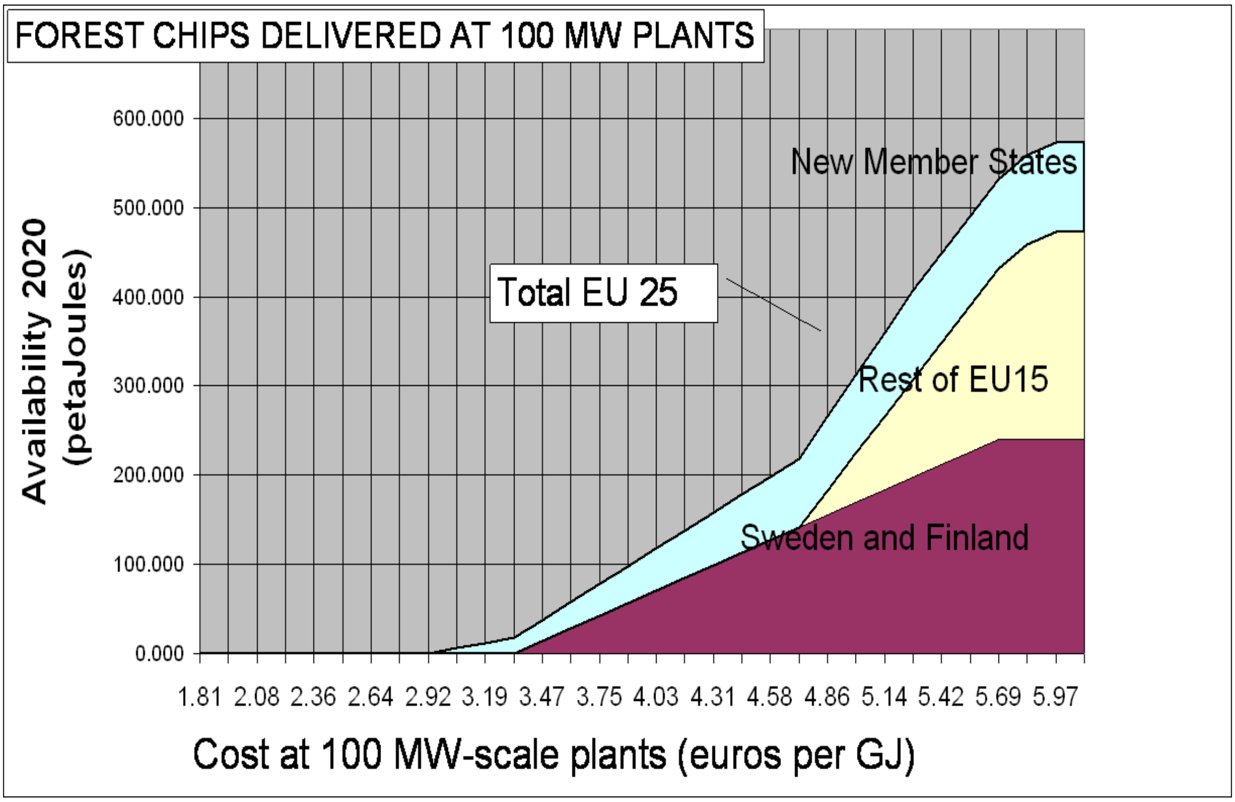

RESIDUES + ROUNDWOOD BALNCE DELIVERED AT 10 MW PLANTS OR AT PULP MILLS
Availability 2020 (petaJoules)
1000.000
800.000
600.000
400.000
200.000
0.000
Total EU 25
New Member States
Rest of EU15
Sweden and Finland
New Member States
Rest of EU15
Sweden and Finland
roundwood balance
residuals
1.81 2.08 2.36 2.64 2.92 3.19 3.47 3.75 4.03 4.31 4.58 4.86 5.14 5.42 5.69 5.97
Cost delivered to 10MW plant (euros per GJ)

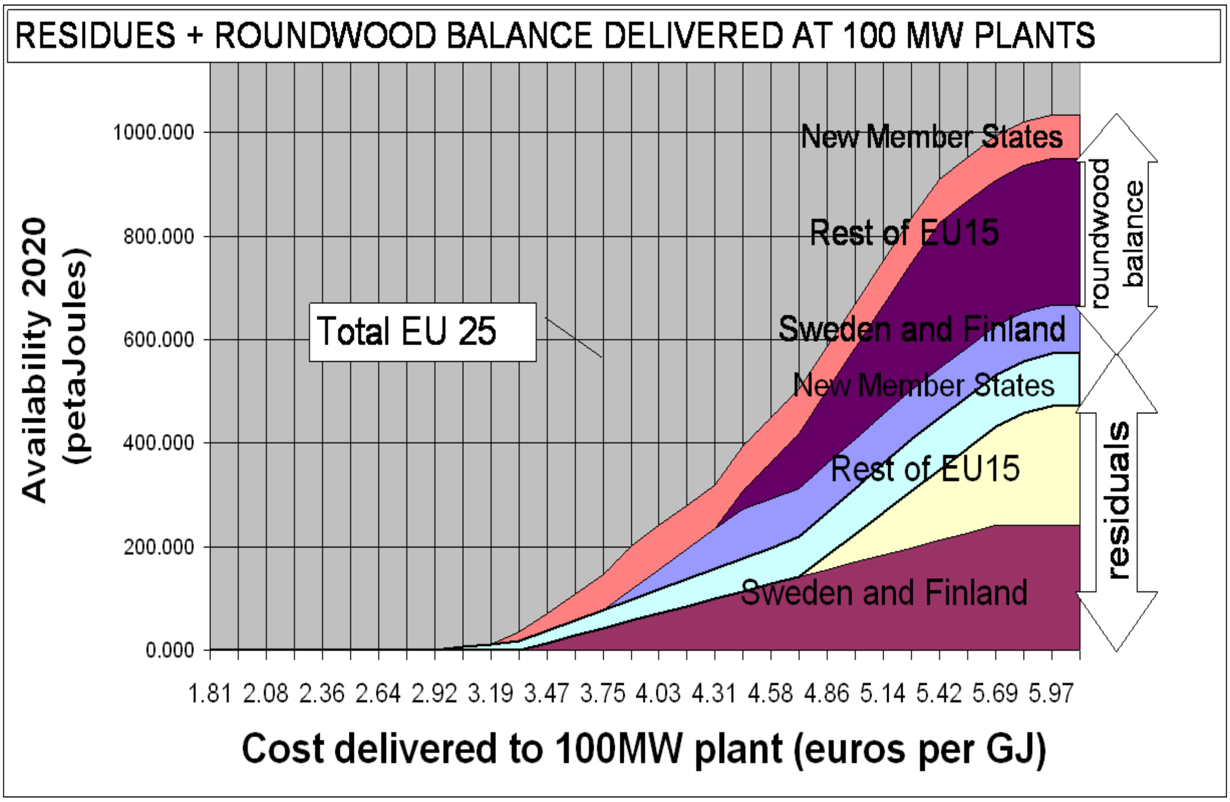

FOREST CHIPS DELIVERED AT 100 MW PLANTS
Availability 2020 (million solid m3)
80
70
60
50
40
30
20
10
0
13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43
Cost at 100 MW-scale plants (euros per solid m3)
Total EU 25
New Member States
Rest of EU15
Sweden and Finland


FOREST CHIPS DELIVERED AT 100 MW PLANTS
Availability 2020 (million solid m3)
140
120
100
80
60
40
20
0
13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43
Cost at 100 MW-scale plants (euros per solid m3)
Total EU 25
New Member States
Rest of EU15
Sweden and Finland
New Member States
Rest of EU15
Sweden and Finland
roundwood balance
residuals


FOREST CHIPS DELIVERED AT 100 MW PLANTS
Availability 2020
(million oven-dry tonnes)
0
5
10
15
20
25
30
Total EU 25
New Member States
Rest of EU15
Sweden and Finland
32.5 37.5 42.5 47.5 52.5 57.5 62.5 67.5 72.5 77.5 82.5 87.5 92.5 97.5 103 108
Cost at 100 MW-scale plants (euros per oven dry tonne)


RESIDUES + ROUNDWOOD BALANCE DELIVERED TO 10MW PLANT OR TO PULP MILLS
Availability 2020
(million oven-dry tonnes)
0
10
20
30
40
50
60
Total EU 25
New Member States
Rest of EU15
Sweden and Finland
New Member States
Rest of EU15
Sweden and Finland
roundwood
balance
residuals
32.5 37.5 42.5 47.5 52.5 57.5 62.5 67.5 72.5 77.5 82.5 87.5 92.5 97.5 103 108
Cost delivered to 100MW plant (euros per oven dry tonne)


FOREST CHIPS DELIVERED AT 100 MW PLANTS
Availability 2020 (petaJoules)
600.000
500.000
400.000
300.000
200.000
100.000
0.000
New Member States
Total EU 25
Rest of EU15
Sweden and Finland
1.81 2.08 2.36 2.64 2.92 3.19 3.47 3.75 4.03 4.31 4.58 4.86 5.14 5.42 5.69 5.97
Cost at 100 MW-scale plants (euros per GJ)


RESIDUES + ROUNDWOOD BALANCE DELIVERED AT 100 MW PLANTS
Availability 2020 (petaJoules)
1000.000
800.000
600.000
400.000
200.000
0.000
New Member States
Rest of EU15
Sweden and Finland
New Member States
Rest of EU15
Sweden and Finland
Total EU 25
roundwood balance
residuals
1.81 2.08 2.36 2.64 2.92 3.19 3.47 3.75 4.03 4.31 4.58 4.86 5.14 5.42 5.69 5.97
Cost delivered to 100MW plant (euros per GJ)

Expert consultation
"EU Forest-based biomass for energy: cost/supply relations and constraints"

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Expert consultation

"EU Forest-based biomass for energy: cost/supply relations and constraints"

Annex

Expert Consultation
Joint Research Centre, European Commission, JRC-EC
European Forest Institute, EFI, Finland

"EU Forest-based biomass for energy: cost/supply relations and constraints"

Overview of the situation in the Czech Republic

Martin Nikl, UHUL

Roundwood harvest projections to 2020 - Forest residues

Expansion factors – according to the study of Parez, Zlabek, Kopriva (1990): Basic volume units in main stands (final felling) of the spruce, pine, beech, oak

Absolute technical constraints (e.g. % which can be picked up)

Technical and economical intersection of residues removal in the Czech Republic is 80% according to the best practice of Forests of the Czech Army, Horovice district, confirmed by other suppliers.

Cost of collection: Collection 1,45 – 2,9 €/m^3. State support for chipping 436,4 €/ha.

Cost of forwarding per tonne-km:
Cost of forwarding 2,18 – 6,55 €/m3 of harvester round wood
Forest residues value on truck landing - Offer price- 2,1 to 3,7 €/m3 of produced chips

Transport distance to existing plant
Up to 10 MWh – economically accessible transport distance 10-30 (50) km (road distance landing-plant)
The 10 MWh and more - economically accessible transport distance 30-100km
Rail transport unefficient – conditions, flexibility, time loss, availability

Transport mean distance vs. plant size for larger plants: same as above

Thinning:
Precommercial thinnings/Cleanings in 0-20 years old stands – residues remain for nutrient circle preservation,
Wood from cleanings - as fire wood to households, lack of evidence
Thinnings of roundwood - used the same way as from final felling, thin wood and residues – question of cost (dispersion, distances, expensive manual collecting or ineffective mechanical extraction)
Thinnings with harvesters – mechanical thinning on rise in CZ

Stumps
Forbidden by law, long time out of use, excessive costs, difficult processing, output contaminated with stones, lower demand
If extracted? Sandy soils, sands, soils enriched by water and humus at flooded plains

Administration costs
Forest owner “subsidizes” wood chip production by 0,55-1,1 €/m3
Indirect cost 0,36 €/m3

Complementary fellings

Growth increment estimate

Growing stock and increments in Czech republic (2005)

Average growing stock is 250,5 m^3/ha.
Total growing stock volume is 663,2 mill. m^3 (minimum top 7cm underbark)
Total final mean annual increment is 11,9 mill. m^3 underbark
Final mean annual increment is 4,6m3 underbark

Wood industry use projection

Accounting: - "unrecorded" fellings

pre-commercial thinnings used in households as fire wood – raw estimates
firewood from orchards, parcs, hedges etc.

Technical and environmental constraints (absolute): soil, slope, access… etc.

Around 60% of commercial (production) forest suitable for residue extraction (Nikl et al, Forest Management Institute, 2006), excluded extreme forest types, forest types influence by water and humus, also excluded all protected forest areas as well as areas with slope steeper than 20°.

Costs of harvesting, costs of forwarding (tonne- km)

Price per unit (m^3, t, GJ)
Harvesting 5,45-5,8 €/m^3
Forwarding 4,54-5,45 €/m^3
Harvesting + forwarding to landing 10,9-16,4 €/m^3
To avoid harvesting of low dimension timber, it would cause more work per unit (m3) and so final price would be higher.
Harvester (mechanized harvesting) 12,7-14,5 €/m^3

Future progression in specific costs (harvesting, forwarding….)

Extensions: What more do we need to know to predict

- effect of increased wood-chip demand on wood prices

Raise of wood prices due to the competition among energy companies, board industry and pulp industry. Big energy companies can offer better prices and wood processing industry is loosing resources.

- potential to increase forest output by managing stand age and fertilization

Wood ash – increased cost but nutrient recycling. Not suitable in Czech Republic due to excessive costs. Forest management would prevent all risks by taking existing measures without a need of added value of recycled ash. Possible regulated application of lime stone or wood ash dose at devastated plots (acid rains damages)

Notes to related topics

Basic factors affecting the price of wood chips

- Input material value
- Forest residues skidding
- Forest residues processing
- Wood chips manipulation
- Wood chips transport
- Wood chips acceptance
- Wood chips storage

Limit factors for forest residues processing

- Gradient (slope)
- Ground bearing capacity
- Stones, obstacles
- Skidding distance
- Hauling distance to the consumption place

Primal/basic material value

- Until 1950s - forest residues were seen as an yield value, nowadays seen more like a cost value
- Residues processing on clear-cut areas- the cost value (burning, raking, crushing, chipping)
- State support for the forest residues chipping is 436 €/ha
- Service value is from 1,5-3 €/m^3 of harvested wood
- Forest owner subsidies chips production- current prices 0,5 -1,1 €/m^3 of harvested wood

Slash value on clear-cuts

- Residues must be removed for 80%, intersection of economic and technical feasibility
- Offer price- from EU minus 2,2 to plus 0,2 €/m^3 of harvested wood
- Price criteria in CZ are very heterogeneous

Forest residues value on clear cuts or in forest stands

- Wood chip price compared to round wood price- from -1,8 to +1,1 €/m^3 of harvested wood
- Price criteria very heterogeneous – influence of forwarding distance, chips volume per 1m^3 of harvested round wood 1 m^3

Forest residues value at truck landing

- Price range- from 2,1-3,7 €/m^3 of produced wood chips

Price Range Summary

Forest residue value	cutting unit	€/ cutting unit		€/ 1 stere of chips	
clear –cut areas	m^3 of harvested wood	- 2,2	+ 0,2	- 1	+ 0,2
slash-piles	m^3 of harvested wood	- 1,8	+ 1,1	- 0,8	+ 1,1
truck landings	m^3 of harvested wood	+2,1	+ 3,7	+2,1	+ 3,7

Price evaluation for forest residues forwarding in harvester cuttings

- Residue forwarding from clear-cut areas to truck landings in €/m^3 of harvested wood
- Residues price from 2,1-6,5 €/m^3 of harvested wood
- Minimum volume of extracted residues is 80% , the rest of slash must be distributed in a balanced way on the clear-cut area and it could not inhibit another reforestation

Costs finding for chipping slash

- Information collection from suppliers is difficult, they are not keen to disclose their internal data, price in €/1 stere of produced chips
- Chipping cost 2,7-4,7 €/1 stere of produced chips

Wood chips manipulation

- Minimization of manipulation with wood chips is necessary, risk of excessive costs
- Wood chips from the wood chipper/crusher must go directly to the hauling machines or containers, need to minimize the forwarding distance
- Procurement prices of the wood chips could not bear the excessive costs of the wood chips manipulation

Wood chips transport

- Wood chips transport is effective to 50km from production place
- Rail transport is always inefficient
- Trucks with trailers are suitable for the distance up to 20km
- Large-volume trailers are best for distances 20km and longer

Cost calculation for wood chips production

	€/1 stere
Owners reimbursement	- 1 - - 0,2
Forwarding	2,1 - 6,5
Chipping	2,7 - 4.7
Indirect costs	0,9
Transport	1,8 - 2.7
Total average costs	6,6 – 15,1

Coefficients for wood chips conversion from wood residues (soft wood, humidity 50%)

	solid m^3	stacked cubic metre(stere)	ton	dry ton	gigajoule
solid m^3	X	2,3	0,7	0,35	5,7
stacked cubic metre(stere)	0,4	X	0,3	0,15	2,4
ton	1,4	3,3	X	0,5	8
dry ton	2,8	6,6	2	X	16
gigajoule	0,18	0,4	0,13	0,06	X

Wood chips acceptance (units in use)

- Stere of provided raw material
- Ton of provided raw material
- Gigajoule inherent in provided raw material (GJ/ton, GJ/m^3)
- Gigajoule produced from provided raw material (GJ/ton, GJ/m^3)

Wood chips storage (Simanov 1992)

		Number of month of the wood chips storage							Total
		1	2	3	4	5	6	7	
Volume loss	%	3,0	5,5	5,5	5,5	5,5	3,0	3,0	31,0
Real volume	%	97	91,5	86	80,5	75	72	69	X

Other notes and examples of costs and prices on Czech market (1€ = 27,5 CZK)

- slash burning = 1,8 – 2,2 €/m^3
- slash removing and cleaning = 327 €/ha
- price EU 2,9 to 4.4 for 1m3 of residues skidding
- wood chips manipulation + EU 3.6 – minimize!!!
- wood chips production costs = 9.1-29 €/m^3
- Wood chip price 43,6 €/GJ
- Average price of wood chips = 29 €/ton
- Average price of sawmill residues – 18,2 €/ton (transport costs included)
- moisture evaluation EU 21,8- 90,9
- lost of heating capacity during storage , composting process is starting after 6 months of storage
- slight use of bundling technology

Conclusions

- Wood chips market does not exist, it has only a regional character
- Limiting factor is a low procurement price of the wood chips in proportion with costs
- Presumption is wide technology development for energy use of forest residues

European Commission

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Abstract
This document include the presentations of the Expert Consultation on EU Forest-based biomass for energy: cost/supply relations and constraints held in Joensuu (METLA) on 18-19 September 2007. This workshop was organised by the JRC in cooperation with EFI and METLA. The main target of the workshop was to have discussion and to arrive at a consensus on EU25-2020 cost-supply curves for forest resources and about the comparison of different studies and models about the availability of residues from felling, complimentary felling and roundwood diverted from industries. The workshop was also about collection and gathering of extra input data required and methodology needed for extensions.

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